# REPORT OF THE WORKING GROUP ON SCIENCE & TECHNOLOGY FOR THE SIXTH PLAN (1980-85)

PLANNING COMMISSION
NEW DELHI
(DECEMBER 1980)

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सत्यमेव जयते

PLANNING COMMISSION

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(DECEMBER 1980)

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GOVERNMENT OF INDIA
DEPARTMENT OF SCIENCE & TECHNOLOGY
Technology Bhavan
New Mehrauli Road.
New Delhi-110029.

PROF. M. G. K. MENON
SECRETARY

My dear Shri Narayan Dattji

The Planning Commission constituted a Working Group on Science and Technology for the Sixth Five Year Plan (1980-85) under my chairmanship. The Group was constituted by office Memo. No. M. 12018/ 83/80 S&T dated 12th September, 1980 and 15th September, 1980. The Group completed its work on the basis of five meetings held on 18 and 24 September, 9 and 14 October and 6 November 1980. The notifications regarding the composition of the Group and the terms of reference are given in Appendix I.

I have great pleasure in submitting to you the Report of the Working Group.

The Group is aware of the many shortcomings in the Report. A considerable part of this stems from the very limited time allowed to the Group for the preparation of the Report. However, I would like to state that if the major recommendations made in this report are accepted and implemented, in the spirit in which they have been made, this would lead not only to a renaissance of Indian science but also result in a wider and more significant impact of science and technology on national development.

In preparing this Report, the Group has received considerable assistance from Shri N. R. Rajagopal of CSIR. The team at INSDOC under Shri V. Ramachandran has worked always at short notice, and very often over holidays and during late hours at night, to produce drafts on a successive basis for the Group to consider and discuss. I would like to place on record our deep sense of gratitude to Shri Rajagopal and Shri Ramachandran for their support and cooperation without which the work of this Group could not have been completed in this time frame.

It has not been possible within the time available to have the Report sent to all the members of the Working Group for their signature before submitting it. It was decided at the last meeting of the Working Group that members would send their comments in writing concerning the draft which had then been presented to them; and that these comments would be suitably incorporated, and the Report finalised by the Chairman with the assistance of the Member-Convener; this has been done. On matters of detail, if any member has further views, he could communicate them to the Planning Commission.

India has built up a large and highly capable infrastructure in the field of science and technology. The scientific community has already contributed tangibly to national development over this period. The problems that we face are such that any solutions for these would have to include massive and sustained efforts in the fields of science and technology. If the recommendations made in this Report are implemented, it is our conviction that science and technology could become a major force for economic and social change; we are at the point where a real breakthrough and a take-off are possible. It is the hope of the scientific community that this opportunity will not be missed.

With kind personal regards,

Yours sincerely,
Sd/-
(M.G.K. Menon)
22 December 1980

Shri Narayan Datt Tiwari,
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New Delhi-110001

**Working Group on Science & Technology for the Five Year Plan (1980—85)**

**Composition**

| | |
|---|---|
| 1. Prof. M. G. K. Menon,<br>Secretary,<br>Department of Science & Technology,<br>New Delhi. | Chairman |
| 2. Prof. Y. Nayudamma,<br>Distinguished Scientist,<br>Central Leather Research Institute,<br>Madras. | Member |
| 3. Dr. S. Varadarajan,<br>Chairman and Managing Director,<br>Indian Petrochemicals Corporation Ltd.,<br>Baroda. | Member |
| 4. Prof. Rais Ahmed,<br>Vice-Chancellor,<br>Kashmir University,<br>Srinagar. | Member |
| 5. Dr. H. K. Jain,<br>Director,<br>Indian Agricultural Research Institute,<br>New Delhi. | Member |
| 6. Prof. G. P. Talwar,<br>Jawaharlal Nehru Fellow,<br>All India Institute of Medical Sciences,<br>New Delhi. | Member |
| 7. Shri Lav Raj Kumar,<br>Chairman,<br>Bureau of Industrial Costs & Pricing,<br>New Delhi. | Member |
| 8. Dr. G. S. Sidhu,<br>Director,<br>Regional Research Laboratory,<br>Hyderabad. | Member |
| 9. Shri A. Rahman,<br>Chief (Planning),<br>Council of Scientific & Industrial Research,<br>New Delhi. | Member |
| 10. Secretary,<br>Department of Electronics,<br>Lok Nayak Bhavan,<br>New Delhi. | Member |
| 11. Secretary,<br>Defence Research & Development,<br>New Delhi. | Member |
| 12. Chairman,<br>Atomic Energy Commission,<br>Bombay. | Member |
| 13. Chairman,<br>Space Commission,<br>Bangalore. | Member |

14. Director General, Indian Council of Agricultural Research, New Delhi. — Member

15. Director General, Indian Council of Medical Research, New Delhi. — Member

16. Vice-Chairman, University Grants Commission, New Delhi. — Member

17. Shri T. R. Satishchandran, Adviser (Energy), Planning Commission, New Delhi. — Member

18. Shri M. Satyapal, Adviser (I &M), Planning Commission, New Delhi. — Member

19. Dr. G. Rangaswamy, Adviser (Agriculture), Planning Commission, New Delhi. — Member

20. Shri M. R. Raman, Joint Adviser (S&T) Planning Commission, New Delhi. — Member-Convener

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CONTENTS

# Report of the Working Group on Science & Technology for the Sixth Plan (1980-85)

## INTRODUCTION

1.0 India has had a long and distinguished tradition in science, from accomplishments of ancient times to great achievements during this century; the latter have, prior to Independence, related largely to pure research carried out in educational institutions. It is essentially since Independence, largely through the vision and support of Jawaharlal Nehru and later of Prime Minister Indira Gandhi, that an organised effort was made to develop a capability and infrastructure, covering a wide spectrum of science and technology, to support national endeavour at all points, and to develop a strong and selfreliant nation. At the time of Independence, our scientific and technological infrastructure was neither strong nor organized in comparison with those of the developed world. This had resulted in our being technologically dependent on the skills and expertise available in other countries during the early years after Independence. *In the little over three decades since Independence, an infrastructure and capability, largely commensurate with meeting national needs, has been created.*

## ACHIEVEMENTS DURING THE LAST THREE DECADES

2·0 The crucial role of science and technology as an instrument of social and economic change has been appreciated, and the rapid development of science and technology, and of its application, accepted as a major objective of planning. This trust in science is embodied in the historic Scientific Policy Resolution of the Government of India adopted in 1958. In the last 30 years or so, 119 universities, affiliating about 1650 colleges, five institutes of technology, 150 engineering colleges and about 100 medical colleges, and three hundred and fifty polytechnics have been established; and about 150,000 qualified scientific and technical personnel are produced every year. The total stock of scientific and technically qualified manpower is estimated at 2·5 million, ranking India as the third largest complement of such manpower in the world, occupying a unique position among developing countries. Simultaneous with this growth in scientific and technical education, about 130 specialized research laboratories and institutes have been established under the aegis of : the Indian Council of Agricultural Research; the Council of Scientific and Industrial Research; the Indian Council of Medical Research; the Departments of Atomic Energy, Science & Technology, Space; and the Defence Research & Development Organization. In recent years, public and private sectors, assisted by attractive fiscal incentives, have also established over 600 in-house research & development laboratories, largely to meet their internal technological requirements. A relatively new but important development in the last 15 years is the rapid growth of consultancy organisations to provide engineering design and consultancy services, and act as the bridge between research institutions and industry. There are now over 150 such firms of varying size and capabilities employing over 20,000 technologists. The total expenditure on science and technology is now close to 0·6 percent of the GNP*. [The data in this paragraph is based on R&D Statistics 1976-77 of DST (Data on the important resources devoted to S&T activities—particularly on the human and financial resources).]

2·1 Political independence has thus been matched by increasing technological independence in many areas. A range of industries, from the small to the most sophisticated, have been established, covering wide areas of utilities, services and goods, and a large number of technologists are now familiar with their operations. There is now a reservoir of expertise well acquainted with the most modern advances in basic and applied areas, that is equipped to make choices

*In defining this percentage, the exact definition of what constitutes S&T activities is important; and there has been considerable variation in the definition adopted by various countries as well as by institutions within the country.

between available technologies, to absorb readily new technologies and provide a framework for future national development. Scientists and technologists have distinguished themselves not only in lecture halls and laboratories but also in factories and fields; and in conceptual planning and formulation of strategies and in their implementation. *Indian scientists and technologists have demonstrated on many fronts that, given clearcut objectives and tasks and necessary support, they can fulfil national expectations.* The relevance of a large part of the investment and effort in Indian Science and Technology to, and its correlation with, national development can be well established.

## THE PRESENT POSITION AND THE PERSPECTIVE FOR THE FUTURE

3·0 Over the past few decades, the growth of science and technology in the advanced countries of the world has been phenomenal. The frontiers of knowledge have been moved forward in unbelievable fashion, and new areas have emerged with clearly great potential for the benefit of mankind. These strides have taken place in the developed countries. The reason for this is because 97% of the world R&D is carried out in the advanced countries and the developing countries, with their share of 3%, have not been able to contribute as they should have.

3·1 While the *total stock of scientific and technical manpower in India appears large at first sight*, as a proportion of the total population it does not compare favourably with that in the advanced countries or even some other developing countries. The fact is that the science and technology content of Indian society, as it is today, (as borne out by the total national investment in this sector, the number of technically qualified personnel, facilities for science and technology education and research, size of technical services, etc.) is low in comparison to the size and population of the country. *A large part of the total stock of S & T manpower is not actually engaged in activities that can be construed as scientific and/or technical.* Even more significantly, *the quality of these personnel varies widely*; there will be need for significant reorientation and upgrading of a large proportion of this stock of manpower, through appropriate training programmes, if they are to be effectively utilized to meet the real needs. It is evident that *in large areas of economic activity, relatively obsolete cost-ineffective technology continues to be applied; the pace of scientific and technological innovation remains unimpressive; and the adoption of the available scientific and technological knowledge is tardy. There are many gaps in new important fields* and in the ranks of leadership and in excellence. While in the early years after Independence, there was a rapid expansion in university education, an increase in the number and size of facilities and in the formation of new institutions, all of which created a sense of elan, few new institutions or new major departments have been started recently, particularly when compared to the manner in which science has been developing with new areas being opened up that have great relevance for our development. In universities and several other institutions, the support provided has not kept pace with the increased need for better facilities. There are wide disparities between facilities available in a few central universities/IITs/National laboratories and other universities. The developments in recent years of a wide variety of new techniques for analysis of minute quantities of materials exceedingly precise and reliable measurements that can be carried out at great speed, their recording and analysis to give a set of observations through the use of micro-processors and high capacity computers, the deployment of a multitude of such techniques simultaneously to bear upon a single problem, the quick elimination of incompatible results and hypotheses and the emergence of a solution, have created immensely greater opportunities for the establishment of new theories. Conventional laboratories and slow experimentation in isolation have yielded place to multi-approach studies. Obsolescence in techniques and instrumentation occurs at a rapid rate; and new facilities and additions are needed every few years. We have clearly lagged behind here. In a large number of areas our capabilities are almost 20 years behind those in the advanced nations; and also behind those established recently in some developing countries. The competitive capability, in international terms, of our scientific community has been impaired, and this has prejudiced the provision of experience of modern science, backed up by modern technology

and instrumentation, to the large majority of graduate and post-graduate students, thereby affecting their level of appreciation of new science and their capabilities for research. *There is serious lack of coordination between manpower requirements* (in terms of areas and levels of training and numbers) *and the actual training of personnel*, which has *led to serious shortage of qualified and trained manpower in many areas.* On this aspect, in conclusion, it should be stated that, while significant advances have taken place on the science and technology front in India over the past three decades, the gap between what obtains in the country and in other advanced countries in terms of infrastructure and capabilities has significantly widened, due to the much faster rate of progress in those countries. *There is, therefore, no room for complacency on the basis of our past accomplishments.* It should be stressed that the point being made here is not that the widening gap across the whole front of science and technology be closed for its own sake or for reasons of prestige. Our purpose in drawing attention to this widening gap is to bring home the point that *major advances in science and technology have taken place during the last 20 years which have opened up wholly new areas, created completely new approaches and techniques, and introduced new concepts that are highly relevant for our developmental activities. An appreciation of these advances, and of the need for selective support of a high order in specified areas is what we would like to propose on a short-term basis. In the long term the country must initiate a series of measures now to ensure that the gap is progressively narrowed.*

3·2 In the area of application of science, a high degree of success has been achieved in several fields in agriculture and in specific mission-oriented projects such as in atomic energy and space. In the earlier period, a continuously adverse foreign exchange situation, and threats to national security at different times, were met, to some extent, through the application of domestic science and technology in the substitution of imports. However, the increasing emphasis on cost effectiveness in establishing domestic production, and the need for exports, (which are crucial in the current context of large foreign exchange outflows on account of the continuously increasing price of oil), now poses a new challenge to the use of domestic scientific and technological talent in the future; there is a serious danger that this new emphasis could lead to greater insistence on provenness looked at in a narrow sense, and averseness to risk. This danger becomes large in the absence of suitable mechanisms, (both administrative and financial), to adapt and force technological development to a point of satisfactory performance and demonstration, and also the acceptance of risk. *Calculated risk-taking and the development of risk-reduction through systematic scientific effort has yet to be promoted adequately.*

3·3 *A detailed strategy for major technological breakthroughs, development of world class technologies appropriate to our priorities and resources and oriented to enhance our exports is therefore to be formulated.* The importance of working on the basis of an export-oriented strategy and/or technologies relevant to this, is that in this area one is forced to be competitive on an international basis; and cannot take shelter behind protected domestic markets and high cost approaches.

3·4 While *linkages and mechanisms for the effective application of science are deficient in most fields*, this lack is especially serious in the optimal use of natural resources and in areas such as energy, health and medicine, population control, ecology and environment and integrated industrial and rural development. This has also led to an insufficient use of science generated, and total lack of appreciation of capabilities in universities and national laboratories, giving rise to the often expressed feeling that the fruits of science and technology have not adequately reached the bulk of the population, and have not contributed in sufficient measure to planned economic and social growth. Consequently, these deficiencies are tending to reduce the level of confidence in science and technology to deal more effectively with the economic and social problems of the country. While there are exceptions to this, *it is clear that the major investment areas in our Plans require a much more deliberate and sustained application of science and technology than hitherto. This requires not only financial support for S & T activities but linkages between the various sectors (educational, R & D establishments, industry and Governmental machinery) and policies conducive to the use of endogenous efforts. Instruments for policy formulation and task implementation in this regard are*

*lacking at present. When we consider the magnitude and dimensions of India's problems of eonomic and social development, associated with the vast and increasing population and immense poverty, especially rural poverty, it becomes clear that massive application of science and technology has to be an essential component for their solution. Our human resources need to be made effective in reaching solutions and for this the inputs that only science and technology can provide are essential. Science and technology must now be considered a vital input in all investments, on par with capital and trained manpower, although it has a longer gestation period; the latter implies advance planning beyond the normal five year framework. Science can and must establish new heights for achievement and endeavour, which are big enough to provide the challenge and excitement for the country's best talent.* This will generate pride and self-confidence, as well as new innovative ideas and solutions which go beyond mere import substitution. *With the much lower costs at which S & T activities can be carried out in India, compared to that in other countries, science and technology is the one resource, which, more than any other, provides the greatest advantage; and it is, therefore, logical for us to base our strategy for economic and social growth on this important resource.*

3·5 *Some deliberate measures are called for to see that the best and well trained among our post-graduate students of science and technology are provided adequate incentives to take up research as a career, and that areas are defined and supported, that best serve national interests and priorities, towards which such talent can be directed or encouraged to work on.* There are situations where, on the one hand, we have pockets of excellence, in terms of sophisticated manpower, in some areas with no exploitative base, and on the other hand there are vital areas crying out for expertise. Such mismatch needs to be avoided. Our R&D institutions have had a tendency to work on a large number of programmes that have going on for years, with a fair proportion of obsolete equipment and manpower, and to carry out imitative research. We need to modernize them and provide them new and major challenges that will stretch them to the full.

3·6 *The concept of separating the total financial resources into Plan and Non-Plan and discussing the Plan allocations by themselves, as currently being done, is not certainly relevant to decisions on investments in S & T;* and perhaps not relevant in many other sectors as well. This has resulted in the continuance of a great deal of activity under the head "Non-Plan" which may have outlived its utility. What is needed is to take stock of the existing infrastructure of an Institution (land, buildings, equipment, staff in terms of numbers, skills, capabilities etc.) and analyse the tasks that it could be expected to, and should, accomplish. *All programmes that are underway, (even if currently being implemented under the Non-Plan head), as well as new activities that the institution could and should take on, should be discussed together to work out an order of priorities.* Programmes should then be taken up in this order of priorities, and adequate resources should be provided for them. The minimum for the latter will be at the normal level of support provided during the previous year or five years, (in the case of Annual Plan and Five Year Plan respectively), with a growth rate to take care of escalation of prices, increments in pay, additional payments of dearness allowance as well as a small growth rate. In addition, new resources should be provided, to the extent possible, to take on new tasks in the order of priorities already worked out. This approach will result in an analysis of the total efforts of an institution, the weeding out of programmes of low priority, or that have not yielded results over long time periods, and thereby the use of resources in a manner to potentially yield the best results. Planning in this context (and which the Planning Commission has to ensure) should be based on broad perspectives: S&T needs flowing from national priorities and investments; areas of S&T work; inter-institutional and inter-agency coordination; conformity with charters of institutions, their infrastructure and background. Administrative and financial aspects should contribute to sound personnel policies, better utilization of funds etc., all of which are to support and foster research. They are not to be treated as ends in themselves. *At present the administrative and financial aspects tend to be looked at purely in terms of conformity with Government directives, many elements of which are inapplicable if accomplishment of scientific objectives has the main priority.*

3·7 *Science and technology must help to speedily improve production through better efficiency and*

*fuller utilization of capabilities already created in the various sectors of the economy.* Technology has to be oriented to improving productivity. *It has to help in the creation of more employment opportunities and in the reduction of drudgery, especially of the weaker sections of the community and of women. It should strengthen the nation and reduce vulnerability. Self-reliance must be at the very heart of S and T planning; and there can be no other strategy for a country of our size and endowments.* The achievement of our development goals has often been impaired due to several national disasters like floods, droughts and communicable diseases; S&T has an important role to play in eliminating these or mitigating them; for this, instead of short term ad-hoc approaches, long term strategies need to be worked out. Problems of extreme poverty, sought to be mitigated through the minimum needs programme, are also well known. Scinence and technology has an important role to play in finding national and long-term solutions for such disasters and national problems. *The full potential of science has to be utilised for eradication of irrational attitudes which tend to hold back the nation from the path of progress.*

3·8 The successive Plans in the past have helped to create a large research infrastructure, but the general emphasis has been on quantitative expansion. *In the Sixth Plan we need to stress the qualitative aspect of science, its modernization and upgrading and effective application through appropriate linkages.* The total role assigned to science and technology must therefore be to develop on a long term basis a sound base in science, in competence and in skills. Shorter term plans must harmonize with this ultimate objective, which will have a gestation period extending well over one five year plan, and must be to:

attract, (and retain), the very best and young talent to contribute to science and technology and achieve originality and excellence in international terms;

improve and transform the existing structure of science and technology for this purpose (e.g. Support for exciting areas of scientific activity; greatly improved standards of teaching of science in our schools and colleges; greater involvement of scientists in defining the tasks that they are expected to perform; better career prospects and amenities for scientists and technologists; improving the mobility of scientists within the country etc.); and

establish much more effective linkages in organizational form, and a policy framework, to ensure effective utilization of science and technology to meet economic and social objectives; and identify major new areas of science and technology of special significance to the country; and in some of these areas invest in an optimal manner in individuals and institutions so as to achieve technological break-throughs in the shortest possible time.

3·9 *For a country like India with a large proportion of people afflicted with poverty, the only solution seems to be in terms of development through industrialization and modernization of agriculture. Major S and T efforts are called for to achieve this goal, with export as one of the dominant features of development.*

3·10 The level of investment and changes in the organizational system and practices that we would recommend for the Sixth Plan are part of a longer term strategy of rapidly maximizing the recognized indigenous capabilities to national advantage, and to bring these to a level of excellence in international terms in selected areas in the shortest possible time. There are several components to this effort. First there is *need to consolidate and strengthen the existing infrastructure; a principal area for investment and new approaches in this would be the education sector which has been allowed to run down badly in recent past. We would like to emphasize the importance of basic research in the overall effort relating to science and technology. There is need to create new institutions and support thrust areas of importance to scientific development and/or to national development,* where it is possible to make an impact with our resource base. *Science and technology must be brought to bear on the problems of the weaker and more vulnerable sections of our society and improve the quality of life for them. There is need to set up new policy instruments and linkages,* in

the absence of which the benefits of the scientific effort do not accrue in economic and social spheres to the extent desired and possible. *There is need to improve the climate of science and morale of the scientific community.* These and other aspects of our approach are discussed in the succeeding sections.

## S & T AND EDUCATION

4·0 *The first priority must be to nurture talent by a substantial improvement in the general science and technology facilities in universities and research institutions. We are deeply concerned about the extent to which the University Science system has been allowed to run down through lack of support in recent past, a trend which if allowed to continue may result in an irretrievable situation. The polytechnic-system must also be greatly enlarged and improved* to provide competent supervisory personnel that are suitable for production enterprises, and thereby avoid waste of graduate and post-graduate talent. The current pressure to which the universities are sujected in terms of the enormous intake of science students should be reduced; *the stream going in for science as a career should be separated from those going in for science as a part of a liberal education. The ten-plus-two system of higher secondary education should be effectively brought into use uniformly in all regions,* taking note of the opportunities that it provides for filtration at the successive levels of 10 and 12 years of school level education. This filtration will only succeed if the alternative channels for vocational training, and later for gainful employment, are taken care of. The guiding principle for opening up such channels should be the provision of equal opportunities for those who leave school but do not take up science as a career, so that maximization of employment potential as part of an efficient production set up becomes a reality. If this can be made to work it will facilitate the more genuinely interested students taking up science as a career, and providing this smaller but more effective number with the right facilities for training. Science education in schools should also be so planned as to sustain and improve on the quality of S&T manpower. It has been observed that there now exists a gap between production and employment of qualified scientific manpower, particularly in the advanced areas for which facilities are no wide-ranging. An appropriate planning mecha nism to bridge this gap has to be devised.

4.1 The higher educational institutions with their research facilities are a unique base for the training of competent scientists and technologist Traditionally, they have been the citadels o learning, contributing significantly to advancin the frontiers of knowledge. Some of the mos significant discoveries in science have made i the universities. And this has been true i the Indian context over the first half o this century when the major high level scientifi effort was essentially in the universities. Recent ly the role of universities in this regard has no been very impressive. In making this statemen it must be clarified that there are very fine scien tists working within our educational system an highly competent work is being accomplished but the point being made is that this is becomin a smaller part of the whole effort. With the rapi expansion of the number of institutions an students without the corresponding inputs by wa of facilities the role of universities as advance centres of teaching and research has been erode leading not only to the weakening of scienc teaching and research but also adversely affect ing the climate so essential for higher learnin The need today is, therefore to restore to the uni versities their proper image as centres of highe learning. Although it would be unrealistic t expect all the members of the academic com munity to take up research in addition to teachin *there is an urgent need to revive the concept o integrating teaching and research* so that in 10 t 15 years from now our universities present different image and are restored to their recog nized position. Research does not necessaril imply the acquisition of a Ph. D., on which ther has been so much emphasis in recent past, leadin to the generation of a large number of Ph.Ds o doubtful quality. The emphasis in research ha to be on the approach, attitude and methodolog

4.2 The integration of teaching with researc (in its true sense), in the universities, will have a far-reaching effect on the quality of teaching itself. Further, providing facilities for research at some level will enable not only utilisation of this vast resource of scientific manpower, o

research of value to science and the country, but also to identify within it persons of high quality who could then be provided with special facilities. *It is necessary to have a mechanism of selectively encouraging outstanding individual scientists and viable groups of scientists to undertake advanced research comparable to what is being done in the developed countries.*

4.3 It must be realised that great deal of unutilized potential exists in our colleges and universities demanding attention. This should be developed. Not all research relates to the frontiers of science. A great deal of useful research may be of a more routine nature, which does not call for great originality though it would demand training, skills, objective thinking, innovativeness and the use of the scientific method and yield results that are useful and rewarding. For all these reasons, integration of research with teaching is extremely important.

4.4 Facilities available in universities at present are largely inadequate. In most cases, lack of support in terms of instrumentation is a serious handicap for research. Instrumentation as an in-built facility has therefore, to be provided; and for this purpose *indigenous production of instruments has to be stepped up*. That these and similar other facilities should be increased need not be overemphasized, because it is in the general interests of not only the universities, but also agencies such as CSIR, DAE, ISRO, ICAR, ICMR, the economic ministries etc. that the resources in the education sector are considerably augmented, since the manpower that these agencies need comes from the University Sector. Moreover, *as the benefits of these researches will extend to several sectors of the economy, State Governments and industries should also share in funding research in universities.* The university system will also have to ensure that these facilities are properly maintained and fully utilized for which staff at adequate levels of skills with appropriate emoluments and recognition are deployed.

4.5 *Linkages between national scientific agencies/laboratories/public sector enterprises and academic institutions have to be stregthened through several measures. A mandatory requirement could be imposed that a certain percentage, (say 5%) of the R&D budget of Govt. scientific agencies (including the economic ministries) and public sector enterprises should be spent in the academic sector.* Simultaneously, the absorptive capacity of academic institutions needs to be raised by the *revamping of rules for sponsored research and for consultancy which are excessively restricted at present. The present barriers in the mobility of personnel, and in communication between educational institutions, various categories of research organisations, production undertakings and Governmental policy making structures impede scientific and technological progress. Research positions in the educational and training system should be open to scientists in industrial research organisations for concurrent appointments and be provided for; joint research should be encouraged between universities and industrial research organizations; and university scientists should be seconded for periods of time to or given consultancy assignments in industry.* There does not appear to be any significant administrative problem in the temporary exchange of personnel between academic institutions and government laboratories located in the same city; and yet there is very little of such exchange. *Necessary managerial arrangements should be worked out to ensure such exchanges* (including with institutions outside the city) under a *policy directive*.

4.6 Universities and colleges should be encouraged to undertake applied research, useful for the regions in which they are situated. The problems of a particular region can be fairly unique and intrinsic; and the best way that the S&T trust could be made in finding out solutions to those regional problems would be to make use of the local human resources. It is here that the role of universities is to be emphasised. *There should be an intergrated approach both at the Central and State levels, to take up problems that the people of a region face, by utilizing universities and other higher institutions of learning and R&D laboratories located in particular region.* These could be coordinated by the State Committee for S&T. The problems could relate to hilly regions, Himalayan regions, the North-Eastern region etc; there could also be problems arising out of regional imbalances and dispari-

ties of economic development. Universities could play a useful role in participating in some of the multi-disciplinary projects of relevance to the various regions, identified by agencies and Government departments both at the Centre and in the State.

## BASIC RESEARCH

5.0 *Basic research is important not only for its own sake, but also because of the solid foundation it provides for applied research and development.* By definition, basic research has to be carried out at the frontiers of human knowledge; and can only be carried out by those with originality and innovativeness of a high order. Successful accomplishment of basic research automatically results in the creation of manpower of great intellectual quality, with self-confidence, and with the ability to find new and innovative solutions to problems. There are many areas of basic research today that are very expensive in terms of resources, both financial and manpower. Therefore, one has to be selective in the areas chosen to ensure that real progress can be made. Basic research would largely be supported at institutions of higher learning such as Universities and IITs, and institutions specially designated for the purpose (Tata Institute of Fundamental Research, Indian Institute of Astrophysics etc., etc.). In addition it should also be carried out to some extent in the National laboratories where it will, through the atmosphere it generates, improve the capabilities, for applied research. *Adequate funds needs to be provided for support of basic research.* With the continued emergence of interdisciplinary areas, it is important to grow the newly-developing broad-spectrum activities where many of the classical disciplines such as Physics, Mathematics, Chemistry etc. are brought to bear, rather than attempt to build isolated peaks on a narrow basis.

5.1 With our preoccupation to foster research programmes of a highly applied nature, we have not been able to pay much attention to these advancing frontiers of science. While we should strengthen the universities for carrying out advanced research in the frontiers of science, *there is a definite need to set up a few new research institutes in some selected important areas* such as molecular biology, plasma physics, immunology, miscrobiology including biotechnology etc. *The new institutes must have a strong mandate for theoretical and pure research.* It is important that a beginning of this kind is made immediately if the gap is not to widen.

## MEASURES AND MECHANISMS TO FACILITATE THE PRESENT INFRASTRUCTURE TO ACHIEVE NATIONAL OBJECTIVES

6.0 *It is apparent that the present system of links between various sectors concerned with generation application and utilization of endogenous know-how is inadequate, often virtually non-existent, and this has created frustration both among scientists and technologists and potential users. A major effort in the Sixth plan must be to establish greatly improved links* which will have to be enlarged continuously thereafter and modified in the light of experience.

6.1 It is only in recent years that a number of enterprises and a few departments have set up in-house R&D organizations. Most of these are small; and in the first instance, have been concerned with providing assistance in establishing process and product standards, in substituting imported raw materials and intermediates and in carrying out product improvements based on feedback from the market/user. Success in these efforts, though of limited scope, has enabled these R&D organisations to gain confidence to deal with the greater challenges posed by more far reaching technological innovations. A major initiative in the Sixth Plan will be to induce public and private enterprises to enlarge these nascent R&D organisations to grow rapidly and to create new ones to engage in this task of promoting technological innovation. This is being encouraged through the various financial incentives in the area of taxation that have been provided recently by Government. This will be further facilitated by the *appointment of managers of these research and development organizations to the boards of directors of the enterprises,* so that the pursuit of technological innovation becomes an integral part of corporate planning. While this relatively easy in public enterprise, (and should be supplemented by such other steps as *appointment of distinguished scientists and technologists from*

*academic institutions/national laboratories, etc. to their boards, and the appointment of suitable national laboratories as institutional consultants to particular enterprises*) special measures need to be adoped to encourage this in private enterprises: Financial institutions that frequently participate in the financing of these enterprises, in a substantial manner, can assist in this.

6.2 A major lacuna in the research system is the serious inadequacy of testing, calibration, standards and quality control laboratories; and this significantly affects the optimal use of national resources, and health, environment and safety aspects in use. *The Sixth Plan should include the commencement of a comprehensive programme which will establish national standards and expand the existing laboratories, test houses and certification centres (that can include recognition of privately owned centres that will provide these services to other entrepreneurs and government departments)*, so that in due course these can cover a large range of activities all over the country.

6.3 *Efforts directed at concentrating resources on well identified projects of an inter-institutional/interagency and multi-disciplinary character in thrust areas of science as well as in areas of technological application, will have to be intensified.* This will require the consolidation of the existing infrastructure and growing the potential of a number of institutions of wide-ranging capabilities and creating some new ones as well as the introduction of specific coordinating mechanisms. There is also need to follow the task-oriented approach as far as possible in the implementation of programmes as suggested. Nodal points, with the specific responsibility of coordinating such programmes, will need to be identified, and wherever necessary, strengthened

## INSTRUMENTS RELATING TO POLICY FORMULATION AND IMPLEMENTATION

7.0 To carry out meaningful S&T planning and to thereafter ensure effective implementation it is essential to have a properly orchestrated functioning of the administrative/economic Ministries or Departments, the Planning Commission, the apex body for S&T policy, the Department of Science & Technology and the major agencies. It is necessary to define clearly the roles and objectives of these various elements and render them compatible with one another. It may also be necessary to alter the present structures and evolve new systems in which R&D laboratories, departments and production units are brought together, so as to ensure compatibility with each other in the matter of technology generation and delivery, its transfer and further diffusion. *It is important to create on an urgent basis, proper instruments relating to policy formulation for science and technology and for S&T planning.* The new mechanisms would have to take into account the existing units concerned with S&T planning in their respective spheres of activity.

7.1 The administrative/economic Ministries and Departments are vested with executive responsibilities in different sectors of the economy. It has been the past experience that there is inadequate correlation between R&D decisions and activities on the one hand and investment and production decisions on the other; or between R&D scientists and decisions relating to import of know-how. *What is, therefore, important is to ensure that in all respect areas of priority in the Plan where large investments are to be made, the S and T component is clearly identified and broken down into tasks that can be assigned to various institutions capable of working on them, whether under the concerned department/agency or otherewise, and wherever necessary new capabilities are built up. There is, therefore, a need to have in these Ministries and Departments, particularly, those economic Ministries concerned with large investments, properly structured information, planning and analysis groups staffed with professional scientists and technologists, and headed by senior scientists technologists who will function as Scientific Advisers to the Ministers; it has to be ensured that their views are given appropriate consideration.* Separate S&T budgets will need to be created in the Central Ministries and Departments where they do not exist at present. The work of special Committees for Implementation of S&T Projects (SCIP) will have to be institutionalised. The Scientific Advisers will be supported by appropriate technical back-up for professional, information gathering and



5—234 S&T/81

dissemination, planning and analysis that are relevant to the S&T tasks. Amongst other things, it shall be the responsibilities of the Scientific Adviser to help the concerned ministries take steps for the implementation of the S&T Plan programmes in that a sector making fullest use of all existing national capabilities. A suitable mechanism for coordination, review and monitoring of S&T programmes would have to be evolved for this purpose. Inter-ministerial committees of action, monitoring and evaluation in which there are representatives of concerned agencies, research institutions may meet periodically. The reports will be made available to the Planning Commission, S&T apex S&T body and Cabinet Committee for S&T.

7·2 With the provision of scientific advice within the economic ministries, *the Department of Science & Technology will have the responsibility for formulation of the science and technology policy for the country as a whole,* (*taking guidance from the apex body for S&T*) *catalyzing and promoting special research efforts or institutions, especially in their nascent stages, and advising the Government on all policies that affect science and technology*. In this it will play the role of a coordinator, mobilizing the expertise available in the agencies, departments/ministries and universities. *It will also service the apex structure* (such as a National Committee on Science and Technology) that will critically assess the progress of science and technology policies in relation to the aspirations of the people and in relation to the achievements in advanced nations, and which will also provide advice on scientific matters that are referred to it by Government.

7·3 *The Department of Science and Technology will constitute a strong scientific group on futuristic studies, to perform the functions of a think tank for science and technology*. This group must monitor on a constant basis new developments in the field of science and technology all over the world, analyze their relevance to the Indian economic and social scene, and recommend appropriate measures for the country to benefit from these advances. The group will also have an important role to play in perspective planning relating to economic development through the application of new scientific discoveries.

7·4 With the assistance of the Department of Science and Technology, the apex body will arrange for meetings of the scientific community on various issues of science and technology in which large numbers of young scientists and technologists will be encouraged to participate. The apex body would be concerned with ensuring the preparation of State-of-Art reports from time to time in different sectors identification of critical S&T gaps in the national endeavour and long term basic/applied/developmental goals. It linkages with the Planning Commission could be achieved by having the Member (Science) of the Planning Commission on the apex body. The reports from this body will be submitted to a special Committee of the Cabinet on Science & Technology that will be constituted to consider all issues related to science and technology policies.

7·5 The Planning Commission's role is primarily one concerning the optimal allocation and utilization of national resources to fulfil national aspirations that are essentially social, economic and cultural in character. Since S&T has an important role to play in specifying the manner in which these aspirations can be met in the shortest possible time at minimal cost, *it is important for the Planning Commission to have a highly competent science and technology group* to enable it to analyse the plans of economic ministries and state governments in terms of S&T; only then will it be able to discern the S&T tasks that will have to be taken in hand to ensure self-reliant fulfilment of the objectives of the Plan. This is essential for the integration of science and technology plans with the investment plans that are proposed. The S&T group, in coordination with the Department of Science and Technology and the Department of Economic Affairs, will also assist the Planning Commission in ensuring that all bilateral and multilateral foreign technical assistance programmes and agreements harmonize with the national science and technology plans and policies.

7·6 The development plans normally indicate physical targets, by sectors, to be achieved at the end of the Plan period. The plans also show the fiscal inputs required for achieving the targets. The methods that would need to be employed

have been left to the implementing organisations and generally undefined. *Science & Technology has an important role to play in the accomplishment of these tasks at a minimum cost and maximum benefits to the society.*

7·7 Further, support for S & T has largely implied support for certain sectoral agencies and the financing of R & D projects on a limited scale in the educational system or in the national laboratories. When one talks of planning for self-reliance, the approach has to be long-range in character, with wider objectives and much greater integration of efforts than has been the case hitherto.

7·8 *It has to be recognised that the time scales involved in the cycle from scientific research to utilization are much longer than the five years characteristic of a Plan period.* We have therefore to project the S&T needs that will arise during next Plan period and beyond, and arrange for the related S&T work to be initiated during this Plan. This is particularly true for large projects such as in the fields of coal utilization, oceanography, aeronautics, biotechnologies, major items of equipment and systems needed for defence communications, various sectors of industry etc. It is clear that the S&T effort can become fully successful in meeting national needs only when perspective plans formulated by the planning Commission take cognizance of the time scales characteristic of S&T time cycles.

7·9 The rigorous implementation of these science and technology plans will be supported by (i) carefully pursuing the stipulation imposed in industrial licensing and in other regulations that public and private enterprises must establish suitable research and development facilities; and (ii) in also enlisting the assistance of financial institutions and banks that provide capital for economic activity. These financial institutions can must assist in; the proper evaluation of technology and the need for foreign technology where applicable; risk taking in the use of indigenous technology; facilitating the horizontal transfer for technology and technological experience gained in the operation of domestic plants; establishing expert organizations such as for specialized maintenance, corrosion prevention, energy conservation and utlization of new alternate energy system; pollution abatement system, in the export of technology etc. The important role that development banks could play in the promotion of these activities has not been fully recognised. *The linkage between S&T and development banks has to be strengthened and used as a strategy for development.* Some of the areas in which development banks could play a useful role are: evaluation of projects and pre-investment studies; identification of gaps in the total technology spectrum; decisions regarding technology vis-a-vis environmental protection; technologies for cottage, small-scale and medium industries; seed capital and risk capital; setting up of proven plants; and help to qualified unemployed scientists and technologists. Further, *the appointment of scientists and technologists to the boards of directors of these financial instetutions can assist them play their role effectively and this can be further supported by these institutions nominating scientists and technologists to the boards of directors of enterprises to which they have extended substantial financial assistance.*

7·10 *The activities of NRDC need to be radically modified so that, apart from licensing indigenous technologies, it vigorously promotes research and development.* NRDC should also concern itself in evolving mechanisms for dissemination/transfer of technology, including horizontal transfer of technology. It should make concerted efforts, along with the technology generators, for export of Indian technologies, and mutual transfer of technology between developing countries. Towards meeting these objectives it should :

(a) sponsor research in new areas of future-significance, and promote the development of modern, efficient and cost effective technologies;

(b) set up pilot plants & process demonstration units (P. D. U. s.); and get prototypes of instruments/equipment fabricated/manufactured indigenously; and

(c) evolve mechanisms for technical risk evaluation, and invest risk capital in commercial plants set up with indigenous know-how.

*It should be adequately funded for these activities.*

7·11 The Inventions Promotion Scheme of the National Research Development Corporation must be altered radically to impart a sense of exciting challenge to inventors, through such means as advance indication of areas of special importance in the country in which handsome reward will be made for innovation and technological breakthroughs.

7·12 *There has to be a National Register of foreign Collaborations. The prime contractor of any project must be Indian; there must be a firm commitment to associate appropriate Indian R & D activities with all import of know-how, and thereafter a commitment to ensure a scale of investment in R & D for the absorption of the imported know-how and subsequently for its adaptation, improvement and conversion to new technologies.*

7·13 The import of technology should be preceded by advice tendered by competent groups in the larger interests of the country. The imports should be so planned as to result in their internal dissemination and further development as far as possible. One way of ensuring that the Indian firms which import foreign technology do set up themselves or ensure adequate R & D facilities for the adaptation, assimilation and improvement of imported technology is to associate appropriate design engineering and consultancy groups of proven capability. It may be necessary to recognize and encourage existing groups and promote new groups in areas where they do not exist now.

7.14 *The present procedure for administrative approval of the import of technology gives formal notice to the domestic S&T sector of the existence of an industrial demand for such a technology much too late often only at the licensing-committee state.* Furthermore, the present procedure puts the onus on the domestic S&T agencies, to demonstrate to the authority concerned with authorising technology import, that import is not required. Industries and user ministries do their technology shopping abroad first, fix a collaborator and then come to the approval authority, where they confront the domestic S&T supply system. This procedure needs to be reviewed and changed. The onus should be on the seeker of foreign technology be it an industry or a "user-ministry", to demonstrate to the satisfaction of the approval-authority that import is necessary, because requisite technology-elements in type and quality, are not available in the domestic technology market. The potential importer must first shop in the domestic market and demonstrate that he has done this before seeking approval for import. And in the case of major areas, there must be clear indications of the planning crarried out, including efforts made well in time, in conformity with the norms of the technology development cycle, to develop the necessary technology; and further, proposals on the manner in which it is proposed to absorb the imported technology and to develop it further.

7.15 *A strong information base is the prerequisite for an S&T plan* with self-reliance as one of its principal objectives. Since information is needed not only for the understanding of current status but also for anticipating the shape of things to come, a strong base for pursuit of intellectual efforts in the direction of technological forecasting, information analysis, R&D management etc has to be created. We have to think in terms of instituting computerized networks for handling of information to meet the requirements of policies, trends of research, monitoring on a global level, resources availability, industrial, technological and market intelligence.

7.16 Each decision relating to the S&T effort requires the assessment, organization and direction of resources, manpower and institutional capacities. Further, a decision in one area has relevance to other areas of science and technology; it has national and international repercussions as well as impact on man society and environment. It is, therefore, important to promote studies in areas of :

(i) Science and technology policy;

(ii) Science and society dynamics; historical social and ethical aspects relating to the developments of science and technology and their impact.

(iii) Problems arising out of international dimensions of science and technology, including research on global problems

issues like transfer of technology and linkages of scientific programmes with socio-economic and political policies.

(iv) Development of techniques in such areas as Science Planning including criteria of choice, working out of priorities, resource allocation, monitoring and evaluation of research etc.

(v) Forecasting and assessment of technology.

(vi) Working out models/ strategies of development.

These should be entrusted by the Planning Commission and the Department of Science and Technology, under the overall guidance of the apex body, to various centres in the country that have been set up and are working in these areas.

7.17 The basic philosophy underlying S&T Planning has to be one of setting sights on the future, with self-reliance as one of the major objectives. Naturally we have to adopt the strategy of perspective planning. By its very nature, *S&T endeavour has a long gestation-period; and since the investment made in S&T now will yield results at a future date, objectives- both long-term and short-term-should be so enunciated as to be in consonance with those in the other socio-economic sectors, at a future date. Simultaneously the overall objective of the growth of S&T capability will also be enmeshed with them.* The optimal strategy will be to strike a balance between the two in such a manner that they have a symbiotic relationship.

## SCIENTIFIC TEMPER

8.0 Science is a force for economic as well as for social change. Since Independence there has a tremendous growth of science, with the major effort being directed towards its use to bring about economic development. The tradition of concentrating on technical work has had primacy and *very few scientists have taken upon themselves the responsibility of creating a scientific outlook in society.* This has resulted in the continuation of the medieval outlook, value systems and social norms in Indian society.

8.1 *The task of creating scientific temper is a vital necessity, as repeatedy stressed by Jawaharlal Nehru. It is important not only for society but for the very growth of science itself and its utilization in the development process.* There need to create a scientific climate and to involve people at large in discussions on various issues of science and technology which affect their lives. For fulfilling the social obligations of science there is need for considerable commitment and efforts on the part of scientists; for their efforts to be effective, significant resources and commitment on the part of Government will be required.

8.2 There are many dimensions of science that need to be projected. These are briefly :

(i) Dissemination of knowledge about natural phenomena, life etc. and information about technological artefacts.

(ii) In the dissemination of scientific knowledge and information on technological innovations, special attention is required to be given to the national effort and future possibilities for the country. This is necessary to ensure the development of a sense of national pride in the achicivements of the country and confidence in the future.

(iii) There is a need for promoting public debate on major issues of science in the country, particularly on problems such as : issues of science policy, investment in R&D and major areas of thrust and their relationship with the needs of the country; problems connected with development, import and use of technology in relation to national goals, impact on resources and manner of their utilization; gains from science and technology and the sections which benefit from it; problems dealing with ethical and other related issues engendered by the growth of science etc.

(iv) Discussion and debate on scientific truths technology, social values and beliefs.

(v) There is urgent need for writing books in different Indian languages for teaching. and popularization of science. The emphasis in these books should be

on developing an understanding of science as a value system, and as a social movement, and not merely to communicate facts.

(vi) Scientific institutions can play a great role in disseminating information about the achievements of science in India through specially printed materials, organizing exhibitions and open days of the institutions and by organizing discussions on recent developments. The role can be further augmented by *establishing a chain of museums as well as by organizing mobile museums and exibitions. The concept of Vigyan Mandirs should be revived.*

(vii) *There is need to develop software for popularization of science and of rational thinking, through films, radio and television. The mass-media should be mobilized for eradication of superstition and unscientific beliefs* which have been a major factor in the economic and social backwardness of our country. The major objective of these programmes should be not merely to educate people on new scientific advances but to help create a scientific temper and outlook which is absolutely essential for the process of decision making at all levels by the individual, by the family, by social groups and by the country as a whole. *Popular science journals should be subsidized by the government. Voluntary groups involved in the movement of science should be supported.*

8.3 It is time we gave to the idea of dissemination of scientific temper an institutional mechanism with an appropriate design and framework. It may be necessary to consider the establishment of a National Council for Propagation of Scientific Temper; this should be examined further.

## S & T AND HUMAN RESOURCES DEVELOPMENT

S&T can obviously play a significant role in the development of human resources, which is one of the principal assets of the nation, and in the promotion of human welfare. In the coming years, the benefits of S&T must percolate more efficiently to the vulnerable sections of the community and the backward areas of the country. *For promoting the applications of science and technology for the benefit of the weaker sections, special programmes would have to be devised in the Sixth Plan.*

## S & T FOR WEAKER SECTIONS

9.0 A more coordinated and vigorous effort than in the past is needed to equip suitable persons from socially backward groups and weaker sections of the society to play a purposeful role in the S&T areas. Consortiums of S&T institutions could be formed in each district to provide the needed technical training and back up for the implementation of special programmes for Scheduled Caste and Scheduled Tribes and the weaker sections of the society. The State Councils for S&T could play an important role in arranging for these programmes.

9.1 It will be the endeavour of the appropriate major S&T institutions to follow an integrated strategy which will aim at increasing production and productivity in agriculture and allied sectors based on better use of irrigation and improved technology. Programmes in the areas of agriculture, animal husbandry, village and small industries that are of special relevance to the weaker section of society will receive special emphasis. In the hill areas, afforestation, soil conservation and watershed management has to be assigned high priority. Alternative land management systems may have to be introduced to make shifting cultivation unnecessary. There is also need for introducing high-value crops backed by processing and marketing, particularly in the north-eastern region. New technologies based on processing of local raw materials to give high value-added products which will minimize transportation costs and capitalize on the locational advantage of cool climates will also have to be developed.

9.2 A development programme for the desert areas needs to be implemented both in the hot

and cold arid zones of the country. The emphasis will be on arresting desertification through activities which restore the ecological balance, stabilize sand dunes and facilitate soil and water conservation. Plantation of shelter belts, adoption of better water harvesting techniques and development of pastures to sustain livestock economy will have to be vigorously pursued. S&T programmes for improved agricultural and animal husbandry practices would be intensified in cold and arid zones.

9.3 The district level S&T consortium will help to prepare a portfolio of economically viable projects for ensuring the optimum utilization of local resources.

## S&T AND RURAL DEVELOPMENT

10.0 It is necessary to emphasize that *application of existing knowledge to the solution of neglected problems of development*, especially in inter-disciplinary areas with an additional socio-political deminsion, *often demands highly created and innovative efforts*, and an application of a analysis capability of a high order, which is typical of many S&T endeavours.

10.1 *Rural technology should not be taken to mean primitive technology or technology of yesterday.* A determined effort is needed to bring the fruits of modern science and technology, as applicable in their circumstances, within the material, financial and skill resources of rural people. While searching for and improving upon such technologies, which increase employment opportunities for our people and improve their quality of life, we will have to bring to bear the powers of the most modern science. We have to ensure an appropriate mix of small, medium and large scale technologies, in a manner consistent with our long-term interests.

10.2 *A national rural resources corps of young professionals should be organized* to cover, in the beginning, the tribal, drought and food prone, and hill areas. *A similar corps of professionals trained in managerial skills should be developed for helping the small and marginal farmers.* The first group could be of very great assistance in providing the needed support for implementing effectively the employment-generation and agricultural and industrial programmes, as well as the minimum needs programmes, in the sectors such as rural health, rural water supply, rural roads, rural energy supply, housing and urban development, nutrition and elementary and adult education. The second group has the potential to make a significant contribution to the processes of transfer of new agricultural technology to millions of small and marginal farmers who have continued to lag behind. These farmers need management support in the form of agro-services of various kinds in our villages, blocks and districts; we must create support of this kind through a large number of young professionals trained in modern management techniques. Also *a coordinated research project should be organised which will help to evolve models for the more successful kind of management centres that would become increasingly relevant to Indian conditions.*

10.3 In order to ensure scientific and technological back up for the national rural employment programme (NREP) it is proposed that *an All India coordinated research project for technologies for landless labour be prepared and jointly undertaken by major scientific agencies and technical institutions;* and professionally qualified and motivated youth mobilized for service in rural areas. The S&T programmes would naturally relate to areas in agriculture, animal husbandry, sericulture, foresty, land reclamation, soil conservation etc. Cultivation and propagation of medicinal and aromatic plants, easy-to-operate technologies for the recovery of active principles from locally available plants etc. will also form part of the strategy of application of S&T to rural development. There is need for the development and application of many technologies that are relevant under Indian rural conditions which can lead to gainful employment, generation of skills and reduce the rural to urban migration.

10.4 "S&T Camps" will be organized in hill and tribal areas for undertaking specific tasks such as eco-development, organization of project-oriented marketing etc. with the help of young scientists and technologists.

## S&T FOR WOMEN

11.0 The question of developmental activities related to women vis-a-vis science and

technology has two aspects. First, there is the contribution by women to the development of science and technology. Secondly, one has to consider as to how science and technology can contribute to the improvement in the life and status of women generally. As regards greater involvement of women in science and technology, it is felt that the following areas deserves special attention :

(a) science teaching in girls' schools and colleges;

(b) greater enrolment of women in engineering, agricultural, veterinarty, fisheries and forestry colleges;

(c) better personnel policies to enable them to look after their families as well as continue full-time or part-time employment; and

(d) their involvement in the decision making processes including opportunities for placement higher levels of decision making.

National educational programmes should be so developed as to pay greater attention to training both boys and girls to share responsibilities at home. The idea is to promote the concept of symmetrical families with shared responsibilities between husband and wife. Restructuring institution, imparting of new skills to rural women, and training in cooperative marketing for women or some of the other programmes that need be taken up.

11.1 Application of science and technology to the improvement of the life and status of women will depend upon the development of : (a) home technologies; (b) suitable agricultural technologies; (c) technology for improvement of productivity. Forestry, sericulture, handloom and crafts like pottery could be considered potential segments of women's work where application of simple technology can go a long way in improving their productivity and economic status and give them enough time to participate in programmes for their educational and other development.

11.2 *There is great need to develop appropriate technologies for those working in the small and unorganised sector.* This is particularly applicable to women facing serious occupational hazards in several professions, leading to avoidable health problems. There is also a need for a co-ordinated research project to find out methods to improve the production efficiency and reduction of drudgery in the occupations of women. In the field of information dissemination, mass media could play a useful role in spreading information on technologies relevant to home needs such as care and maintenance of household gadgets, electically operated utensils, etc.

11.3 *Special cells for promotion of S&T for Women could be set up in the University Grants Commission, CSIR, ICAR, ICMR, Departments of Atomic Energy, Space, Electronics, Science & Technology and Defence Research and Development Organization.* Specific programmes relating to technologies for rural women and warding off of occupational hazards, have to be structured. There is also need to look into the personnel policies for promoting greater involvement of women in S&T.

## S&T IN STATES

12.0 *All States need to set up S&T Councils as an integral part of their planning machinery.* Some states have already made a start in this regard. Such Councils should bring together a broad spectrum of expertise from academic institutions, national laboratories, industries and govt., and including young research scholars and Science journalists, and undertake a continuous review of science and technology policy, priorities, applications and analysis of constraints relevant to the state and region. Promoting location-specific research and technology development should be the major aim of such State S&T Councils.

12.1 One of the specific ways by which these State Councils could foster S&T in their own region could be to associate the national laboratories, universitiy departments, schools and colleges, research scientists and professional scientists in the States, in the identification of areas where S&T could offer solutions. The State Councils could also organize public discussions and debate of S&T policies, plans and programmes being followed or proposed to be

followed, by the various Central and State S&T institutions situated in the States. Dissemination of science and fostering of scientific temper should be an important element in the working of these State Councils. This could be achieved by the publication of special journals in local languages, programmes for the children in schools and "science melas" organised in research institutions in which a large number of people participate. The councils could also commission mobile science museums for purposes of exhibition in rural areas.

## INVOLVEMENT OF YOUNG SCIENTISTS

13.0 *The involvement of young scientists is essential for promoting an interest in science in the youth;* and looking to the future, it is they who would be called upon to provide leadership; *they need to be involved and enthused right at the start of their career.* Having regard to the conditions in our country, this should focus on the age group 20-35.

13.1 Suitable mechanisms will have to be developed for a more purposeful and satisfying involvement of younger research workers in the major scientific establishments, universities, public sector R&D institutions and other organisations supported by government on a continuing basis rather than in an ad-hoc manner. The involvement has to be at the following three levels :

(a) development of the programmes of the institutions/organizations where the scientists are working ;

(b) interaction with the State Councils of Science & Technology; these Councils should have standing committee of young scientists, and for the inter-action to be meaningful it should be decentralized upto the district and block levels, in addition to the State level meetings.

(c) national level : there is need for a proper mechanism at the GOI level for a continuous involvement of young scientists in the formulation and implementation of policies for science. This could be brought about through appropriate Standing Committees of young scientists as well as by organizing regular conferences and meetings.

13.2 There is an urgent need for bringing about a greater awareness among young, (as also older) research workers of the pressing socio-economic problems of the country. The S&T community has to be mobilized for remedying regional and societal imbalances. This will call for considerable attitudinal changes at all levels in the S&T establishments. The personnel policies of both universities and S&T establishments need be restructured so as to facilitate the involvement of young research workers in socially relevant projects. "Science for Development" camps should be organised with specific goals and objectives in different parts of the country, where young scientists can be entrusted with the task of solving specific problems in the areas of eco-development, eradication of health disorders, such as blindness caused by Vitamin A deficiency, propagating family planning etc.

13.3 The younger generation should be involved in discussions relating to self-reliance, import of technology, societal dimensions of S&T, propagation of scientific temper etc.

13.4 Universities should be encouraged to bring about a greater degree of integration among education, research and extension activities, and should initiate operational and action research projects to bring about structured linkages between these sectors.

13.5 There is need for encourging young scientists with a flair for writing in local languages and in English to take to a career of specilization in science communication. Suitable facilities for training for this purpose, and providing them information on a regular basis will have to be created. The proposal for the establishment of a Science Information Bureau, if implemented, would provide suitable feedback between science journalists and research organizations.

13.6 There is considerable scope in rural areas for qualified scientists and technologists to take to self-employment in agriculture, animal husbandry, social forestry, fisheries and small industries. It is, however, necessary to provide a mechanism for giving them the necessary training, credit and other support. The Employ-

ment Exchanges should be developed in such a way that they can also help in providing the necessary guidance to those seeking self-employment. Development banks can assist in providing financial backing for such entrepreneurs. Suitable mechanisms for this purpose need to be worked out.

13.7 It would be useful to form a consortium of the 400 and odd scientific associations existing in the country. A strong, well-knit and interactive S&T community could help raise the morale of young scientists, and promote the involvement of S&T personnel in national development in a much more dynamic and effective manner.

## TECHNICAL COOPERATION IN S&T

14.0 Science and technology in any country is not developed in isolation; there is need for appropriate awareness and understanding of the developments in other countries. Collaborative efforts through multi-lateral programmes, such as those of the various agencies of the UN system or bilateral technical programmes, have emerged as significant vehicles for inter-country cooperation in S&T. It is however, important that such programmes of technical cooperation are enmeshed with the indigenous S&T capability and linked to the S&T Plan. *Amongst the developing countries India has an important role to play in sharing its facilities and capabilities with other developing* (particularly neighbouring), *countries*; such programmes have to be organised on a planned footing, and *specific resources need to be allocated for this purpose*. Development of information systems and the quick exchange of S&T information have to be accelerated in this plan.

14.1 In devising programmes of technical cooperation with advanced countries, aid as such should not be the primary objective. Since the basic infrastructure of S&T is believed to be strong enough in the country, it would be advantageous to look for programmes which calls for collaborative effort, with mutuality, between our scientists and those of the advanced countries. It should be the endeavour of R&D institutions to see that, as far as possible, the stress in the collaboration is governed by the exchange of knowledge on both sides and procurement of specialized equipment from advanced countrie[s]. As regards international programmes in th[e] areas of health, education, flood control an[d] those relating to natural disasters, the primar[y] objective should be one of participation b[y] our experts with a view to contributing to th[e] total pool of knowledge as well as benefiting from what is contributed elsewhere.

14.2 We may be in a position to offer prove[n] technologies to other developing countries face[d] with development problems similar to ours. It would be valuable to do this in the spirit o[f] "Technical Cooperation between Developin[g] Countries." In this regard *the Centre for S&T Non-Aligned Countries and the Regional Centre for Transfer of Technology,* (*under ESCAP auspices*), *need to be supported and developed.*

## S&T AND SCIENTIFIC ACADEMIES AND PROFESSIONAL SOCIETIES

15.0 The large S&T manpower available in the country has to be mobilized towards the objective of accelerating the pace of economic growth of the country. One of the ways of doing this will be *to energise the scientific community, through academies and professional societies. Appropriate assistance will have to be given* for this purpose. These professional bodies have an important role to play in creating a cohesive, integrated scientific community through arranging regular meetings and conferences, publishing high quality journals on a prompt, regular basis, encouraging non-hierarchical, non-bureaucratic objective discussion, critical assessment of scientific work etc.

15.1 In planning of S&T, a sense of the broad perspective involved and a futuristic out look are essential. Gaps in S&T between what exist in our country and that in the advanced countries have to be identified, particularly because S&T is to be used as an important instrument for our future development. Current trends in research have to be studied, state-of-art reports have to be prepared, and technological forecasting has to be restored to in several areas. The expertise available with Science Academies and professional societies could be fruitfully employed for these activities.

15.2 *These academis and societies should interact with educational and training institutions in the matter of curriculum development, retraining and refresher courses for the older groups in the profession, and intensive training for special categories of professionals.* This would ensure a good stock of qualified scientists and engineers at any given time, and a steady flow of highly trained specialists. Also it would build a cadre of scientists & technologists aware of new developments and the emerging areas in various branches of science and technology.

15.3 In the total development scene of the country, in addition to S&T, other aspects of human endeavour have also their complementary roles to play. It is, therefore, but natural that in deciding on the policies and progrmmes in the area of S & T, representatives of society, other than those belonging to the scientific community have a say. What one envisages here is a public debate and discussion of policies and programmes, so that society is involved in decision making on S&T, has a stake in the employment of S & T for its own development, and is given an opportunity to look critically at the impact of technology giving rise to social, economic and ecological change and changes in quality of life. The professional societies and academies could organise such seminars and workshops where the society comes face to face with the decision makers, the scientific communiy and those concerned with implementation at gross-root levels. The academies and societies should work in close collaboration with State S&T Councils and State Planning Boards.

15.4 In the dissemination of science, popularization of science, and on matters concerning impact of science and technology on quality of life etc. the Science Academies and professional societies have a unique role to play. A feedback mechanism linking scientists and society could be created through the academies and societies, by publication of newsletters, magazines etc. both in English and regional languages.

15.5 Professional societies could also take up specific areas/disciplines (leprosy, energy etc.) for preparing programmes for research, extension and training. The principal benefit in their undertaking such endeavours will be the independence available for the members to undertake these activities, unfettered by bureaucratic restrictions and guided by the high professional quality expected from members of such bodies.

15.6 The academies and science societies could also render useful service by taking up such activities as laying down of guidelines for : (a) ethics of science and an accepted code of conduct for scientists; (b) social responsibilities of scientists; (c) criteria for authorship of papers, reports etc. among scientists, particularly when juniors are involved; (d) facilities and amenities for scientists; (e) career advancement of scientists; (f) aspects relating to employer-employee relationship in scientific institutions; and (g) climate for science etc. In addition, they could institute special incentives, awards and medals for outstanding work by the members of the community, particularly at younger levels.

## FACILITIES AND AMENITIES FOR SCIENTISTS

16.0 Indian scientists are part of the society for whose development they are deeply committed. The socio-economic problems faced by the scientists are not different from those of the common man. While recognizing this, it must be stated that *if minimum requirements are not met, it would be difficult for scientists to give of their best in their endeavours which call for dedicated undivided attention and a sense of enthusiasm.* Due to the difficulties related to poor living conditions and low salaries, a large number of scientists and technologists have left India and have contributed significantly to research and development overseas. Many of the younger scientists, in their creative years, have to devote too much of their time to problems of everyday living while they would like to devote their time to thinking and researching. Low salaries, lack of housing, poor and uncertain educational facilities for their children and lack of other amenities and incentives have affected the calibre and morale of scientists. It is time that attention is paid to some of the problems, if research institutions are to be made more creative and greater returns are to be obtained from investments on research. A package of incentives and ameni-

ties on the following lines could be provided to scientists :

(i) Better salary structure and avenues of promotion : (service conditions should be made as attractive as they are in administrative cadres, such as IAS, IFS, etc. for corresponding quality of personnel.)

(ii) Provision of sabbatical leave and liberalization of rules for study leave to enable scientists to improve their professional competence; and permission to apply for posts within the country without any restrictions for promoting mobility.

(iii) Provision of financial assistance to scientists for writing books.

(iv) Housing facilities: scientists are not asking for luxurious conditions, nor even the norms prescribed, but basically a place to stay.

(v) Education of children, in terms of facilities equivalent to Central Schools.

(vi) Transport facilities between their homes and places of work.

(vii) Enhancement of post-retirement benefits and appropriate opportunities and facilities to enable the retired scientists to pursue their research interests.

(viii) Insurance of scientists (and other co-workers) to protect against health hazards and accidents in laboratories.

(ix) Other amenities such as reimbursement of membership fees for recognised professional societies, liberalization of TA/DA rules, encouraging scientists to attend national & international seminars and symposia etc.

(x) The provision of "in-situ promotion", without regard to the vacancy position, as currently practised in the Departments of Atomic Energy, Space etc. (and largely covered by the scheme of "flexible complementing" recommended by the Third Pay Commission), should be made applicable in all areas of S & T endeavour; it is wrong to discriminate between scientists working in different areas and institutions and have special provisions and schemes applicable to only limited categories; and

(xi) Mobility of scientific staff has to be made possible by a provision which would allow service benefits to be transferred from one organization to another.

With regard to these questions it is recommended that a special Committee be constituted to examine in details what could be done within the framework of overall national policies and norms that could improve working and living conditions for scientists taking note of what is expected to them and the manner in which they have to function.

## S & T ADMINISTRATION

16.1 S & T agencies are increasin gly being treated on par with Secretariat Departments, despite structuring of some of them in the form of Commissions designed to operate with flexibility and free of needless restrictions. The anatomy of the structure is rather less important than the physiology of its functioning. Whatever the rational for government's economy instructions from time to time for Secretariat Departments, these measures are proving to be counter-productive in the case of the scientific agencies and tend to supersede the flexibility originally prescribed. The cost-effective utilization of S & T funds, admittedly liberally, provided by Government, requires cost-effective administration and support services. Serious detailed thought will have to be given to matters of delegation of financial powers to the scientific agencies and indeed all other areas of S & T endeavour, and limits to the overseeing role of the Ministry of Finance in respect of these through overall budgets rather than through each items of expenditure.

## MAJOR OBJECTIVES FOR SCIENCE & TECHNOLOGY IN THE SIXTH PLAN

17.0 The Major objectives of the Sixth Plan as such are :

(a) human resources development;

(b) removal of regional imbalances; and

(c) price stability.

17.1 The extent to which S & T can *directly* contribute to the achievement of these objectives is defined by the nexus it has with each and every other sector of the economy by the dovetailing of its plans to those of the sectors themselves. *However, S & T programmes could be so conceived as to progressively have an impact on the various sectors in the achievement of each of these objectives.* For instance, S & T could contribute to the objective of human resources development by programmes in the areas of population stabilization, energy availability, provision of basic human needs such as housing, water, better environment, improved hygienic environment in rural areas, increased employment opportunities by making available alternative technologies, better educational aids at the primary, secondary and higher levels of education, removal of drudgery for women etc. The strategy for contributing to the second objective would be to follow a consortium approach, involving national laboratories, universities and educational institutions, State Councils for S&T etc. to work out detailed plans for regional development in which S&T has an important role to play. Programmes in the areas of energy would contribute to the control of inflation and hence to price stability. Efficient use of available energy, alternative and additional sources of energy (including funding exploration for new sources of oil, natural gas and methane, improved and increased utilization of coal resources, renewable energies etc.) which would reduce the vulnerability to imports and the present heavy foreign exchange outlow, as also increase in productivity are some of the means to achieve this objective. Also, programmes designed to increase the availability of vegetable oils and related universal consumer products, development of fisheries, better utilization of horticultural products, new and innovative methods of food consumption, alternative and unconventional sources of food are some of the ways through which S&T could contribute to the achievement of the objective of price stability.

17·2 In the light of what has been discussed earlier, some of the criteria which have a bearing on setting the goals an charter for the S&T Plan would relate to :—

(a) maximizing the returns from investments already made in several sectors of the economy, and thereby bringing about fuller utilization of the capacities through increase of efficiency and productivity;

(b) ensuring appropriate steps to achieve technological self-reliance through application of modern science and upgradation of technology;

(c) structuring the application of science and technology in different sectors around the theme of conservation and efficiency in the use of energy and appropriate materials, systems, and contributing to alternative and additional energy availability;

(d) bringing about conditions which enable the adoption of science and adaptation of technology oriented to the provision of benefits to the society;

(e) ensuring that the development programmes based on science and technology are compatible with the goal of protection and improvement of ecological and environmental assets;

(f) ensuring its potential for securing a faster growth in the economy commensurate with the improvement in the quality of life of our people and the inculcation in them of a scientific temper; and

(g) evolving of new techniques of crop and animal production so that the country's enormous resources of sunshine, water soil fertility, and above all the human resources, can be fully harnessed to increase agricultural production for the triple purpose of improving the nutritional standards of people, for the generation of employment through Food for Work programmes, and generating a massive export potential. All this must be done without damaging the various life-support systems.

## THE MAJOR OBJECTIVES FOR S&T IN THE VARIOUS SECTORS DURING THE SIXTH PLAN PERIOD WOULD BE :

### ENERGY

Identification of the consumption pattern of energy in industry, transport, agriculture and household use.

Improving the efficiency of production distribution and utilization of energy from all sources.

Development of energy generation through efficient and new forms of utilization of coal.

Development of breeder reactors and utilizing thorium resources for development of atomic energy.

Development of alternative sources of energy, especially renewable resources (solar thermal and solar photovoltaic, wind, biogas).

Use of agricultural residues, new sources of biomass and waste material for meeting energy needs.

INDUSTRY :

Industrial research would be directed to enhance the efficiency of production nationally, and rendered competitive internationally and would be utilized as an instrument of help to other developing countries in their struggle for self-reliance.

CHEMICAL INDUSTRY :

Development and use of alternative feedstocks for the chemical industry such as molasses, alcohol and coal, renewable resources such as carbohydrates, legumes and ocean derived chemicals.

Directing major efforts in the areas of process and product development, process engineering, simulation and optimization.

Building up of consultancy and project execution capabilities.

Directing research efforts in areas where gaps exist such as catalysis, photochemistry, polymers, elastomers, fibres etc.

INSTRUMENTATION :

Effective use of the instruments which have been imported in the country through the establishment of maintenance, service and repair centres at city regional and national levels.

Development and production of sophisticated instruments in areas of large needs (environment, geosciences etc.) Meeting the requirements of schools and colleges.

Application of micro-processors to the area of instrumentation.

ELECTRONICS :

Develoment of micro-electronics on a major scale and its application for micro-processors and computer systems; development of efficient and reliable switching and transmission systems needed for telecommunications, satellite technology; industrial process control; applications and systems for energy, defence, instrumentation. Move from analog to digital technologies. Lasers.

HEAVY ENGINEERING :

Increasing the efficiency of processes and machines with a view to saving energy & improving products; increasing productivity on the one hand and improving the process design on the other.

Development of capabilities for the designing and fabrication of equipment and plants in the areas of fertilizers, petro-chemicals, pesticides, steel and non-ferrous technology, mining machinery, beneficaition technology, power and electrical engineering and machinery for other products such as cement, paper, and machine tools.

Development of systems which can use alternative energy systems for saving of energy and to reduce pollution.

MACHINE TOOLS :

Development of the capacity of the industry to design and manufacture newer and more sophisticated tools and development of supporting technologies to enable the industry to do so.

(Specific areas where major effort would be required automobile, agricultural equipment and machinery, mechanical and electrical equipment and printing technology).

MINING & MINERALS :

Development of new and efficient methods for exploration and exploitation of mineral deposits.

Improvement of efficiencies in mines & plants including modern electronic techniques Recovery of precious and minor (but valuable ) metals persent in base metal ores.

Applied research for pollution control and protection of environment in the mining and non-ferrous metals industry.

TELECOMMUNICATIONS AND BROADCASTING :

Upgradation of technology to modern electronic switching systems and use of digital techniques.

Modernization of facilities in communication equipment and services.

Development of TV equipment, including R&D on colour TV. UHF/VHF propagation.

Improvement of P&T network through satellite communication.

GEOSCIENCES :

Augmentation of meteorological forecasting systems.

Earthquake detection and evalution of seismic risk.

Development of oceanography to fully exploit the living and non-living resources: taking note of national resources of the 200 mile EEZ and Continental Shelf.

AGRICULTURE AND FOOD :

Creating higher genetic Potentials of yields in pulses and oilseeds as major strategy for eradication of protein-calories malnutrition.

Upgrading of country's horticulture resources of fruits and vegetables and development of improved post-harvest storage and processing techniques to minizelosses. Utilization of agro-wastes and biomas for production of energy and various industrial products.

Evolving alternative models of a crop and animal production so that the present highly energy-intensive techniques are replaced with those which aim at combining high levels of production with a high degree of efficiency in the form of a better energy input-out put ratio, through greater dependence on biofertilizers and renewable resources of energy including the solar energy.

Selective mechanization of agriculture both for increased production and to remove drugdgery of farm men and women.

Experimentation with semi-cooked foods for better retention of nutritional quality and for freeing women from tedious house-keeping chores so that their energy could be directed to more productive tasks of nation building.

Development of low-cost food mixed for a balanced diet, particularly for the vulnerable group of underprivileged sections of the society, especially children and lactating mothers.

TRANSPORT :

Optimization of operational efficiency of the existing systems.

Improvement of the quality of engines and systems with a view to saving energy and improvement of designs to meet functional and comfort requirements. Substitution of fuels in present diesel operated systems.

Electric operated vehicles.

TRAINING & EDUCATION

Consolidation and modernization of the educational system to improve its quality.

Selective support for high quality broad-based scientific research.

Improving of syllabi to make education more inter-disciplinary and modernize the concepts in different areas of science and technology.

INFORMATION SYSTEMS :

Evolution of a national information system to help research workers as well as the decision workers.

Updating national statistics on industrial production, industrial licensing, import and export data.

Establishment of machinery for their continuous collection and updating for its

use in policy and decision making. Industrial and Market Information worldwide.

SOCIAL WELFARE :

MEDICAL CARE :

The health programmes have to be coupled with programmes of nutrition and preventive measures.

Development of a system of education oriented towards the promotion of community health and primary health care. Control of communicable diseases (including through new developments in immunology and vaccine production). Full development of indigenous capabilities for the manufacture of drugs required in bulk for most prevalent diseases in the country.

Utilization of full potential of the medicinal plants available in the country by screening them for medicinal properties, ensuring their cultivation and increasing their yield and manufacture of specific drugs.

URBAN SYSTEMS :

Provision of basic amenities to people, in terms of housing, water and energy supply, and rapid mass transport systems within the city, and improvement of the urban invironment.

R&D : on construction materials/technologies, to lower costs, and to go to energy entensive approaches.

ATOMIC ENERGY :

Achievement of self-reliance and self-sufficiency in all critical areas for exploiting the nuclear energy potential for bulk power generation; and use of isotopes. R&D is oriented to development of power reactor systems and for applications of radio-isotopes in industry, agriculture and medicine. The thrust of the R&D efforts in the atomic energy sector in the Plan would, therefore, be towards completion and strengthening of the thermal reactor technology, extensive application programme for utilization of radio isotopes and undertaking work in futuristic areas like fast breeder reactor technology, and ultimately utilization of thorium.

SPACE SCIENCES & TECHNOLOGY :

Development of capabilities relating to: satellite launch vehicles; satellite fabrication; space applications on remote sensing, telecommunications, television etc. and associated technologies.

Some of the general infrastructural areas needing specific attention would be :

Training of science communicators and critics;

S&T Information Systems : Technological and Industrial Intelligence;

Technological Forecasting Methodologies and Techniques ;

Manpower training for R&D Management and Planning for S&T.

## INDICATIVE THRUST AREAS FOR SCIENCE & TECHNOLOGY

18.0 In order to utilize our existing manpower resources and to strengthen the infrastructure of our institutions, so as to leapfrog, into advanced areas of science and technology, it will be nesessary to concentrate on well selected areas of science and technology and provide the requisite amount of resources so that major breakthroughs may be achieved in the selected thrust areas; these must be chosen such that even limited resources can make a great impact. These thrust areas are being indentified, and appropriate priorities assigned, through the process of interaction amongst different groups of scientists and engineers from educational and research institutions as well as from the industry. Many of these thrust areas need inter-disciplinary work encompassing different traditional disciplines such as Physics, Chemistry, Biology, Engineering etc.

18.1 Progress in modern science very largely depends upon the availability of specialised sophisticated instrumentation facilities for detailed and rapid quantitative analysis of various aspects of scientific investigations. Many of these are required in fairly large numbers and have to be made available in different regions to different groups of investigators; a programme for the development and produc-

tions of such instruments therefore needs to be embarked upon. At the same time, it has to be ensured that they are used optimally, and suitable mechanisms have to be evolved for that purpose. Another feature relates to the setting up of appropriate institutional mechanisms to ensure that these new inter-disciplinary areas are pursued by scientists of high calibre, around whom suitable core groups/units may have to be built up, providing them with the necessary facilities including appropriate training programmes, specialised courses career awards schemes etc.

18.2 Some of the indicative thrust areas indentified so far and the corresponding Departments/Ministries/Agencies which might implement them are indicated (pp. 26 to 31).

18.3 It may be mentioned here that some programmes in the thrust areas may have a bearing on development of rural industries such as sericulture, tanning, animal husbandry etc. It would be ensured that appropriate technological back-up will be provided through these programmes for the implementation of the National Rural Employment Programme designed to promote rural public works.

18.4 Also, efforts will be intensified to take up specific programmes oriented to the utilization of existing skills training, provision of additional employment facilities and general development of such sections of our community as the scheduled tribes, tribes of the hilly region etc. The S&T efforts in this sphere will naturally develop around such disciplines as post-harvest technology (mushroom cultivation, prawn culture), cultivations of medicinal, aromatic and other plants of economic value, tanning and paper technology etc.

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INDICATIVE AREAS OF THRUST-MINISTRIES/DEPARTMENTS/AGENCIES CONCERNED WITH IMPLEMENTATION

| S.No. | Thrust Areas | Ministries/Departments/Agencies concerned with implementation (indicative and not comprehensive) |
|---|---|---|
| 1 | 2 | 3 |
| A. LIFE SCIENCES | | |
| 1. **Basic Life Sciences :** | | |
| 1.1 | Molecular biophysics and theoretical biology. | Ministry of Health/ICMR Ministry of Agriculture/ ICAR/Deptt. of Sci. & Technology/CSIR/Ministry of Education/UGC/National Institutions like TIFR |
| 1.2 | Molecular and Cellular Biology. | |
| 1.3 | Developmental biology of multicellular systems. | |
| 1.4 | Neurobiology and mechanisms of behaviour. | |
| 1.5 | Animal behaviour, Ecology and Evolution. | |
| 1.6 | Biology of reproduction. | |
| 2. **Medical Sciences :** | | |
| 2.1 | Immunological control of Tropical and communicable diseases and modernization of vaccine production technology. | Ministry of Health, CMR/IDST/CSIR/DAE/TIFR/Min. of Education/UGC |
| 2.2 | Virology as related to Hepatitis Japanese Encephalitis etc. | |
| 2.3 | Human Neurobiology in relation to mental health. | |
| 2.4 | Fertility Control. | |
| 2.5 | Drug Research. | |
| 3. **Applied Biological Sciences :** | | |
| 3·1 | Genetic Engineering. | Ministry of Health/ICMR/AIICAR/DST/CSIR/Min. of Education/UGC/Department of Environment |
| 3.2 | Microbial Productivity. | |
| 3.3 | Bioms as a source of energy. | |
| 3.4 | Physiology and biochemistry of plants. | |
| 3.5 | Protection of endangered species and preservation of genetic diversity of living organisms. | |
| 3.6 | Ecological balance for sustainable utilization of biological resources, forests, grazing lands and fisheries. | |
| B. CHEMICAL SCIENCES | | |
| 1. **Molecular Structure and Dynamics :** | | |
| 1.1 | Recent developments in spectroscopy such as two dimensional FINMR, Multi-nuclear solid state HRNMR, FTIR spectroscopy and photoacoustic spectroscopy. | DAE/TIFR/Min. of Education/UGC DST/CSIR/IISc/IITs |
| 1.2 | Laser chemistry and laser spectroscopy. | |
| 1.3 | Fast (nano—and pico-second) kinetics involving relaxation and other methods. | |
| 1.4 | Gas phase kinetics including molecular beems and plasma chemistry. | |
| 2. **Solids, Surfaces and Catalysis :** | | |
| 2.1 | Ultra-Micro structure of solids. | DST/CSIR<br>Min. of Education/UGC<br>Min. of Petroleum<br>Min. of Chemicals & Fertilizers<br>DAE. |
| 2.2 | Solid state organic chemistry. | |
| 2.3 | Solid state electro-Chemistry. Energy conversion & storage. | |
| 2.4 | Synthesis and properties of novel materials. | |
| 2.5 | Newer techniques of surface characterization such as electron energy loss spectroscopy, photoelectron spectroscopy, SIMS, Auger Spectroscopy, LEED etc. | |
| 2.6 | Heterogeneous and homogeneous catalysis including catalyst development and characterization and phase-transfer catalysis. | |
| 2.7 | Micelles, Membranes, Reverse osmosis. | |

| 1 | 2 | 3 |
|---|---|---|
| **3. Frontiers of Organic Chemistry :** | | |
| | 3.1 Synthesis of organic molecules utilizing new and innovative synthetic schemes and techniques. | DST/CSIR<br>Min. of Education/UGC<br>Min. of Petroleum/Min. of Chemicals & Fertilizers/Department of Space DAE |
| | 3.2 Newer reactions and reagents. | |
| | 3.3 Mechanisms of organic reactions. | |
| | 3.4 Polymer synthesis and mechanism of polymerization. | |
| | 3.5 Total synthesis of complex natural products and other exotic molecules. | |
| | 3.6 Structure of scarce and complex natural products. | |
| **4. Coordination Chemistry and Organometallic Chemistry :** | | |
| | 4.1 Electron transfer reaction and mechanistic coordination chemistry.<br>4.2 Structure spectroscopy and Photochemistry.<br>4.3 Activation of molecules and catalytic synthesis including reactions of carbon monoxide.<br>4.4 Noval organometallics and their applications in organic synthesis. | DST/CSIR<br>Min. of Education/UGC<br>Min. of Petroleum<br>Min. of Chemicals & Fertilizers |
| **5. New Interfaces of Chemical Sciences with Biology :** | | |
| | 5.1 Biomimetic Chemistry.<br>5.2 Chemistry of Biopolymers and their constituents.<br>5.3 Membrance and Model Systems.<br>5.4 Metal ion interactions with biomolecules. | DST/CSIR<br>Min. of Education/UGC<br>Min. of Petroleum<br>Min. of Chemicals & Fertilizers<br>Min. of Health/ICMR |
| C. PHYSICAL SCIENCES | | |
| **1. Energy :** | | |
| **1.1 New Energy Sources :** | (a) Solar energy through thermal and photovoltaic routes;<br>(b) Biological route (e. g. energy plantations, petro-crops), biomass production and bioconversion, biogas;<br>(c) Wind energy development (materials, devices and systems);<br>(d) Energy conservation and efficiency in industry, buildings, transportation etc;<br>(e) Electrical vehicles development;<br>(f) Energy form waste ;<br>(g) Ocean;<br>(h) Magnetohydrodynamics (MHD); and<br>(i) Geothermal. | DST/CSIR<br>Min. of Education/UGC/IITs<br>Min. of Industries/BHEL<br>DAE<br>KVIC<br>ICAR<br>Deptt. of Power |
| **1.2 Coal :** | (i) Gasification and Liquefaction<br>(ii) Beneficiation<br>(iii) Slurry and other transportation systems. | DST/CSIR<br>Department of Coal<br>Min. of Industries/EIL/BHEL. |
| **1.3 Oil :** | (i) Exploration and production capabilities, particularly offshore.<br>(ii) Conservation.<br>(iii) Improving efficiencies in consumer sectors. | Min. of Petroleum/ONGC<br>Min. of Energy<br>Min. of Industries<br>DST/CSIR |
| **1.4 Power :** | (i) Efficiency Improvement in power system materials and devices. | Min. of Energy.<br>Min. of Industries /BHEL IITs |

| 1 | 2 | 3 |
|---|---|---|
| 1.5 **Nuclear Energy :** | | |
| | (i) Improving thermal power reactors.<br>(ii) Development of fast breeder power reactors leading to ultimate thorium utilization.<br>(iii) Development of capability to move into fusion technology. | DAE |
| 2. **Earth Sciences :** | | |
| | 2.1 Survey and mapping of the country.<br>2.2 Mineral resources for copper, chromium, iron, manganese, tungsten, zinc, lead, nickel, phosphorite and magnesite.<br>2.3 Energy resources including fossil fuels, geothermal and gas.<br>2.4 Improvement in mining extraction technologies.<br>2.5 Remote sensing technologies.<br>2.6 Hydrological Resource survey techniques and studies on hydrological cycle.<br>2.7 Improving the efficiency of water utilization and studies on recycling of the same.<br>2.8 Studies on prediction of natural disasters. | DST/CSIR; Department of Mines<br>Min. of Education/UGC<br>Min. of Agriculture & Irrigation/ICAR<br>Department of Space<br>IMD |
| 3. **Ocean Sciences :** | | |
| | 3.1 Development of Ocean Science Technology for the survey of living and non-living resources—Enhancement of facilities such as Research Vessels etc. | DST/CSIR<br>Min. of Agriculture/ICAR<br>Deptt. of Space/PRL<br>Min. of Education/ UGC/IITs<br>Min. of Defence |
| 4. **Atmospheric Sciences :** | | |
| | 4.1 Meteorology and National Disaster Warning Techniques :<br>(i) Computer modelling techniques, forecasting etc.<br>(ii) Space meteorology.<br>4.2 Cloud Seeding.<br>4.3 Monsoon Systems. | IMD<br>Min. of Communication<br>Deptt. of Food & Agriculture<br>DST/CSIR<br>Deptt. of Space<br>Min. of Education/UGC/IITs |
| 5. **Space Sciences :** | | |
| | 5.1 Basic studies in Astrophysics, Plasma Physics etc.<br>5.2 Satellite Telecommunication.<br>5.3 Satellite Mass communication-Education to Rural Communities (TV etc.).<br>5.4 Remote Sensing—Optical, infrared & microwave techniques.<br>5.5 Satellite launching and training capabilities. | Deptt. o f Space<br>Deptt. of Electronics<br>Min. of Communication<br>DST/NRSA/CSIR<br>Min. of I & B<br>Deptt. of Agriculture<br>Min. of Defence |
| 6. **Nuclear Sciences :** | | |
| | 6.1 High Energy Accelerators.<br>6.2 Nuclear Radiation research in Life Sciences & Agriculture.<br>6.3 Nuclear Medicine. | Deptt. of Atomic Energy<br>Deptt. of Agriculture/ICAR<br>Deptt. of Health/ICMR |

| 1 | 2 | 3 |
|---|---|---|
| 7. **Electronics :** | | |
| | 7.1 Equipment, Instruments and Systems—Quality Control, Medical Electronics, Mining Electronics, Industrial Electronics, etc.<br>7.2 Components and Devices—ISI, VLSI, etc.<br>7.3 Communication—Fibre optics, Digital techniques, etc.<br>7.4 Telecommunication<br>—Communication network, Switching Systems,<br>—4 GHZ, 6 GHZ Microwave systems, etc.<br>7.5 Microprocessors, computers and softwares.<br>7.6 Information Systems; Computer networks, and other systems.<br>7.7 Laser Research. | Deptt. of Electronics<br>Deptt. of Industry<br>Deptt. of Defence<br>Deptt. of Communication<br>DST/CSIR<br>DAE/ECIL<br><br>All Sectors. |
| 8. Materials Sciences—Nature of thrust areas to be identified— | | |
| D. ENGINEERING SCIENCES | | |
| 1. **Aeronautics :** | | |
| | 1.1 Aerodynamics.<br>1.2 Propulsion studies.<br>1.3 Systems development; control and systems engineering. | DST/CSIR<br>Deptt. of Defence<br>Deptt. of Space<br>Deptt. of Electronics |
| 2. **Heavy Engineering :** | | |
| | 2.1 Building up of indigenous capabilities in plants and equipment for the following :<br>(i) Fertilizers.<br>(ii) Petroleum refining and petrochemicals.<br>(iii) Steel and metallurgy.<br>(iv) Mining and ore beneficiation.<br>(v) Port and harbour.<br>(vi) Sugar.<br>(vii) Cement.<br>(viii) Paper.<br>(ix) Heavy machine tools.<br>(x) Electric equipment.<br>(xi) Printing.<br>(xii) Packaging.<br>(xiii) Manufacture of fabrics.<br>(xiv) Heavy Pressure Vessels.<br>(xv) Heat exchangers. | Deptt. of Industry/ Fertilizers/Petroleum/ Steel/Defence/CSIR/DST |
| | 2.2 Aluminium | Deptt. of Industry/CSIR |
| 3. **Steel and Metallurgy** | | |
| | 3.1 Direct reduction of iron ores with solid reductants.<br>3.2 Small Steel Plants.<br>3.3 Removal of ash from coking coal, development of formed coke.<br>3.4 Development of high grade steel alloys and super alloys.<br>3.5 Process improvement in the metallurgical industry to effect saving in energy (for example INRED process).<br>3.6 Development of basic oxygen process for making high alloy steels.<br>3.7 Development of alloy powders and their products.<br>3.8 Development of anti-corrosion products to suit Indian climate. | Min. of Steel/Industry<br>DST/CSIR<br>Deptt. of Coal<br>Min. of Defence |

| 1 | 2 | 3 |
|---|---|---|
| 4. **Machine Tools :** | | |
| | 4.1 Achievement of self-reliance in tools, equipment and machinery particularly in the following areas :<br>(i) Laser Technology.<br>(ii) Plant and equipment for processing industry.<br>(iii) Chemical processing.<br>(iv) Agricultural equipment and machinery.<br>(v) Mechanical engineering industry.<br>(vi) Electrical and electronics industry.<br>(vii) Printing machinery and accessories. | Min. of industry<br>Min. of Agriculture/ICAR<br>DST/CSIR<br>Deptt. of Electronics |
| | 4.2 Development of tools, equipment and machinery for the small scale and unorganised sectors. | DST/CSIR |
| 5. **Light Engineering :** | | |
| | 5.1 Improvement of the quality of products, by developing quality control through the use of sophisticated instruments.<br>5.2 Production techniques and equipment. | Min. of Industry |
| 6. **Housing and Construction Technology :** | | |
| | 6.1 Low cost materials.<br>6.2 Building materials from agrowastes and community wastes.<br>6.3 Building materials for energy conservation.<br>6.4 Offshore structures to exploit marine resources.<br>6.5 Urbanization studies. | Min. of Works & Housing<br>DST/CSIR<br>Min. of Petroleum.<br>Min. of Education/IITs |
| 7. **Transport :** | | |
| | 7.1 Modernization of various modes of transport.<br>(a) **Railways :**<br>(i) Electronics for signalling, communication etc.<br>(ii) Electrification of Railways.<br>(b) **Inland Transport :**<br>(i) Mechanization of boats. | Min. of Shipping & Trans.<br>Min. of Railways<br>DST/CSIR<br>Deptt. of Electronics |
| | (c) **Road Transport :**<br>(i) Development of weatherproof light transport.<br>(ii) Battery operated, light-weight vehicles.<br>7.2 Improvement in the quality of engines to save energy and to increase speeds. | Deptt. of Defence Research & Development |
| 8. Instrumentation—(Thrust Areas to be identified) | | DST/CSIR |
| E. OTHER SCIENCES : | | |
| 1. **Agriculture & Food :** | | |
| | (i) Creation of higher potentials for yield in pulses and oilseeds.<br>(ii) Operational research for closing the yield gaps in cereals.<br>(iii) Cropping systems.<br>(iv) Water management and water use efficiency.<br>(v) Agro-energy research including biomass and bio-conversion.<br>(vi) Transition from non-renewable industrial inputs to renewable biological inputs through nitrogen fixation and microbiological applications.<br>(vii) Soil management and fertility.<br>(viii) Post-harvest technology.<br>(ix) Modernization of horticulture for protective foods.<br>(x) Energy crops for fuel, fodder and feed.<br>(xi) Agricultural management and marketing.<br>(xii) Molecular biology and agriculture.<br>(xiii) Upgrading and conservation of animal resources.<br>(xiv) Scientifically and socially relevant mechanization. | Min. of Agriculture/ICAR/CSIR/DST |

| 1 | 2 | 3 |
|---|---|---|
| 2. **Forestry :** | | |
| | (i) Social and Rural Forestry.<br>(ii) Energy plantation.<br>(iii) Plant-soil-air-water Relationship.<br>(iv) Intensification of wood science and technology. | Min. of Agriculture/ ICAR/DST/CSIR |
| 3. **Environment & Ecosystem :** | | |
| | (i) Rural & Urban Sanitation. | Min. of Works & Housing |
| | (ii) Air and Water Pollution Control. | CSIR |
| | (iii) Man and Biosphere Research. | Deptt. of Environment |
| 4. **Policy Sciences :** | | |
| | (i) S&T Information Systems.<br>(ii) S&T Planning Monitoring & Evaluation Systems.<br>(iii) International Relations in S&T.<br>(iv) Technological Forecasting & Technology Assessment. | DST/CSIR<br>DOE<br>All other related agencies |

## FINANCE :

19.0 The trend of expenditure on science and technology in the earlier Plans is given in Tables 1 and 2. Table 1 gives the expenditure on science and technology between the years 1974-75 and 1980-81. The expenditure for each year has been broken into Plan and Non-Plan and relates to the agencies, departments/ministries where S&T programmes had been identified earlier. In Table 2 the outlays for the previous Plan period, i.e. 1974—79 have been presented for the various agencies/ministries/departments. Since this Plan had to be terminated w.e.f. 1978-79 and another Plan was then prepared for the period 1978--83, some of the outlays had to undergo some alteration. These have also been indicated in the same table.

19.1 The Draft Sixth Plan 1980--85 envisages an outlay of Rs. 90,000 crores as against the outlay of Rs. 71,000 crores envisaged in the Draft Plan 1978--83. However, the sectoral outlays are still being firmed up in the Planning Commission, and the exact break-up of the total outlay for 1980—85 is not yet available to the Working Group; the break-up under the Central and State sectors is also not available. Since the outlays for the S&T programmes will have to be enmeshed with outlays for the corresponding socio-economic sectors, the Working group has made certain assumptions. The first assumption is that the step-up in the outlays for different sectors in 1980—85 could be in the ratio of 90 : 71; this implies that there is no change in the basic priorities and inter-sectoral allocations. Since the purpose of preparing the new Plan is to define a new set of priorities and make corresponding allocations for them, this assumption will not be wholly correct. In the absence of more information, the Working Group had to go by the earlier worked out figures. The Working Group is clear that within a sector there will be need to step-up S&T efforts as compared to the previous Plans. The working Group is also of the view that there is need for higher priority to be given to sectors like Power (including the allied input areas of oil, coal, heavy industry), Irrigation, Health and Rural Development etc. even if there is no step-up percentage of total outlays for S&T programmes of these socio-economic sectors. The Group would urge a step-up in S&T outlays since these amounts are small compared to the total outlays but have the potential of great returns.

19.2 On the basis of indications available present, the outlays suggested are for program mes that may have to be implemented by mo than one agency or department/ministry. Durin the Sixth Plan, the approach would be to fur the programmes under S&T agencies undertakin research development and design upto th stage of competence building and data collectio and to a more limited extent in terms of pil plants or product/process demonstration unit the latter will be in areas where the applicatio is clear and likely. The further requirement for application-oriented efforts in terms of up scaling of technology, extention and field tria etc. would be funded by the concerned minis tries / departments. In addition, certain area of work in S&T agencies such as CSIR particularly those calling for large S&T expendi ture, will be taken up only on the basis of a clear-cut indication of their need/priority in the concerned economic sector; the S&T agency will then take up its part of the programme on the basis of funding provided from the S&T allocation of the concerned economic ministry/department. This is referred to as complementary funding. This would ensure both the rationale for the programmes and their need and also utilization of the technology developed. A suitable mechanism will have to be evolved for such complementary funding of programme in the agencies/research institutions. The creation of Information, Planning and Analysis Groups in the economic ministries and the provision of Scientific Advisers as recommended in 7.1 will greatly assist in the process of reviewing the investment targets in that sector over the current Plan and beyond and breaking these down into tasks that need S&T work to be carried out. This task needs to be carried out with urgency since the concerned S&T agencies must be told as early as possible in the Plan period what tasks they will be called upon to perform and what complementary funding will be provided during the Plan. It might be possible to entrust this aspect of complementary funding and sponsoring of programmes to the Standing Committees for Implementation (SCIP) of S&T projects. It is essential that S&T agencies and research institutions which are to undertake programmes specifically earmarked for the economic ministries/departments would have representation in the SCIP for those various ministries/departments so that interministerial funding is effected easily.

TABLE 1

EXPENDITURE ON SCIENCE & TECHNOLOGY—1975—81

(Rs. in crores)

| gency/Department/ Ministry | 1974-75 | | | 1975-76 | | | 1976-77 | | | 1977-78 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Plan | Non-Plan | Total | Plan | Non-Plan | Total | Plan | Non-Plan | Total | Plan | Non-Plan | Total |
| A. S&T Agencies | | | | | | | | | | | | |
| 1. Atomic Energy (R&D) | 18·24 | 23·64 | 41·88 | 27·18 | 28·49 | 55·67 | 31·02 | 30·00 | 61·02 | 28·91 | 32·21 | 61·12 |
| 2. Space | 17·26 | 13·47 | 30·73 | 22·48 | 14·67 | 37·11 | 23·80 | 15·42 | 39·22 | 22·75 | 15·64 | 38·39 |
| 3. DST | 3·83 | 15·10 | 18·93 | 8·15 | 18·63 | 26·78 | 13·20 | 21·02 | 34·22 | 15·94 | 24·45 | 40·39 |
| 4. CSIR | 9·76 | 22·60 | 32·36 | 11·90 | 25·21 | 37·11 | 14·02 | 27·44 | 41·46 | 18·49 | 29·60 | 48·09 |
| 5. NTH | 0·02 | 0·58 | 0·60 | 0·14 | 0·60 | 0·74 | 0·14 | 0·62 | 0·76 | 0·20 | 0·63 | 0·83 |
| TOTAL 'A' :— | **49·11** | **75·39** | **124·50** | **69·85** | **87·60** | **157·45** | **82·18** | **94·50** | **176·68** | **86·29** | **102·53** | **188·82** |
| **S&T Component under Ministries/Departments** | | | | | | | | | | | | |
| . Heavy Industry | 0·39 | 0·50 | 0·89 | 1·73 | 0·50 | 2·23 | 2·95 | 0·50 | 3·45 | 7·65 | 5·06 | 12·71 |
| . Industrial Development | 0·06 | 0·222 | 0·28 | 0·84 | 0·12 | 0·96 | 1·72 | 0·43 | 2·15 | 2·75 | 0·56 | 3·31 |
| . Commerce* | — | — | — | — | — | — | — | — | — | — | — | — |
| . Steel | 0·22 | — | 0·22 | 0·61 | — | 0·61 | 0·71 | — | 0·71 | 0·97 | — | 0·97 |
| . Mines | — | — | — | 0·02 | — | 0·02 | 0·54 | — | 0·54 | 0·48 | — | 0·48 |
| . Power | 0·40 | 0·29 | 0·69 | 0·47 | 0·38 | 0·85 | 0·84 | 0·40 | 1·24 | 0·70 | 0·64 | 1·34 |
| . Coal | — | — | — | — | — | — | 1·25 | — | 1·25 | 1·25 | — | 1·25 |
| . Petroleum | 1·24 | 0·58 | 1·82 | 1·80 | 0·75 | 2·55 | 1·64 | 1·71 | 3·35 | 1·86 | 1·72 | 3·58 |
| . Chemicals and Fertilizers | — | — | — | 0·07 | — | 0·07 | 0·19 | 0·25 | 0·44 | 0·51 | 0·26 | 0·77 |
| . Electronics | 0·74 | 2·95 | 3·69 | 1·29 | 1·09 | 2·38 | 3·27 | 0·9 | 4·23 | 3·80 | 1·37 | 5·17 |
| . Communications | 1·78 | 1·33 | 3·11 | 3·09 | 2·31 | 5·40 | 4·17 | 3·35 | 7·52 | 4·93 | 4·37 | 9·30 |
| . Information & Broadcasting | — | 0·18 | 0·18 | — | 0·19 | 0·19 | 0·06 | 0·24 | 0·30 | 0·06 | 0·25 | 0·31 |
| . Shipping & Transport | — | — | — | — | — | — | 0·30 | — | 0·30 | 0·64 | — | 0·64 |
| . TCA-IMD & Instts. CA-Dte of R&D | 2·05 | 7·44 | 9·49 | 2·98 | 8·32 | 11·30 | 2·23 | 9·53 | 11·76 | 5·76 | 9·81 | 15·57 |
| Works & Housing | — | — | — | — | — | — | — | — | — | — | — | — |
| Labour | — | — | — | — | — | — | — | — | — | — | — | — |
| Education | 2·40 | — | 2·40 | 5·36 | — | 5·36 | 5·62 | — | 5·62 | 5·87 | — | 5·87 |
| . Health-ICMR | 2·55 | — | 2·55 | 3·20 | — | 3·20 | 4·26 | — | 4·26 | 4·49 | — | 4·49 |
| Social Welfare | — | — | — | — | — | — | — | — | — | — | — | — |
| Rural Reconstruction* | — | — | — | — | — | — | — | — | — | — | — | — |
| Agr.-ICAR | 14·60 | 14·15 | 28·75 | 22·85 | 16·20 | 39·05 | 29·07 | 17·30 | 46·37 | 39·20 | 19·98 | 59·18 |
| Agr.-FRI | 0·21 | — | 0·21 | 0·29 | — | 0·29 | 0·37 | — | 0·37 | 0·61 | — | 0·61 |
| Food | 0·19 | 0·32 | 0·51 | 0·59 | 0·37 | 0·96 | 0·45 | 0·43 | 0·88 | 0·49 | 0·38 | 0·87 |
| Irrigation | 0·27 | — | 0·27 | 0·30 | — | 0·30 | 0·22 | — | 0·22 | 0·38 | — | 0·38 |
| Railways (RDSO) | — | 3·78 | 3·78 | — | 4·60 | 4·60 | — | 4·41 | 4·41 | — | 4·47 | 4·47 |
| TOTAL 'B' | **27·10** | **31·74** | **58·84** | 45·49 | **34·83** | **80·32** | **59·86** | **39·51** | **99·37** | **82·40** | **48·87** | **131·27** |
| GRAND TOTAL (A+B) : | **76·21** | **107·13** | 183·34 | **115·34** | **122·43** | 237·77 | **142·04** | **134·01** | 276·05 | 168·69 | **151·40** | **320·09** |

*Upto 1977-78, included under Deptt. of Industrial Development

| Agency/Department/ Ministry | 1978-79 | | | 1979-80 (RE) | | | 1980-81 (BE) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Plan | Non-Plan | Total | Plan | Non-Plan | Total | Plan | Non-Plan | To |
| **A. S&T Agencies** | | | | | | | | | |
| 1. Atomic Energy | 30·74 | 34·60 | 65·34 | 28·38 | 41·68 | 70·06 | 32·52 | 48·02 | 80 |
| 2. Space | 29·09 | 16·71 | 45·80 | 23·38 | 25·11 | 48·49 | 30·87 | 26·06 | 5 |
| 3. DST | 17·95 | 25·94 | 43·89 | 16·18 | 32·04 | 48·22 | 26·73 | 36·68 | 6 |
| 4. CSIR | 19·14 | 30·89 | 50·03 | 21·79 | 32·49 | 54·28 | 25·64 | 34·81 | 60 |
| 5. NTH | 0·16 | 0·62 | 0·78 | 0·19 | 0·61 | 0·80 | 0·61 | 0·64 | 1 |
| TOTAL 'A' | **97·08** | **108·76** | **205·84** | **89·92** | **131·93** | **221·85** | **116·37** | **146·21** | **262** |
| **B. S&T Component under Ministries/Departments** | | | | | | | | | |
| 6. Heavy Industry | 7·08 | 8·91 | 15·99 | 9·72 | 16·12 | 25·84 | 8·76 | 17·54 | 26 |
| 7. Industrial Development | 2·68 | 1·15 | 3·83 | 1·49 | 2·65 | 4·14 | 1·90 | 0·84 | 2 |
| 8. Commerce* | — | — | — | — | — | — | 0·80 | 1·24 | 2 |
| 9. Steel | 1·97 | — | 1·97 | 4·67 | — | 4·67 | 3·80 | — | 3 |
| 10. Mines | 1·84 | 0·06 | 1·90 | 1·15 | 0·32 | 1·47 | 2·00 | — | 2 |
| 11. Power | 0·87 | 0·73 | 1·60 | 1·22 | 0·96 | 2·18 | 2·40 | 0·59 | 2 |
| 12. Coal | 1·35 | 1·62 | 2·97 | 2·11 | 2·37 | 4·48 | 2·48 | 2·20 | 4 |
| 13. Petroleum | 2·17 | 2·82 | 4·99 | 4·60 | 3·40 | 8·00 | 6·41 | 5·00 | 11 |
| 14. Chemicals & Fertilizers | 0·97 | 0·10 | 1·07 | 3·16 | 0·27 | 3·43 | 3·80 | 0·61 | 4 |
| 15. Electronics | 5·31 | 0·81 | 6·12 | 8·19 | 0·77 | 8·96 | 5·80 | 0·50 | 6 |
| 16. Communications | 5·02 | 5·07 | 10·09 | 5·60 | 4·72 | 10·32 | 6·59 | 5·52 | 12 |
| 17. Information & Broadcasting | 0·06 | 0·25 | 0·31 | 0·22 | 0·30 | 0·52 | 0·36 | 0·36 | 0· |
| 18. Shipping & Transport | 1·04 | 0·72 | 1·76 | 1·78 | 0·77 | 2·55 | 2·00 | 0·77 | 2· |
| 19. TCA-IMD & Instts. CA-Dte of R&D | 6·10 | 9·74 | 15·84 | 9·17 | 11·55 | 20·72 | 14·00 | 12·17 | 26· |
| 20. Works & Housing | 0·21 | 0·67 | 0·88 | 0·20 | 0·71 | 0·91 | 0·12 | 0·14 | 0· |
| 21. Labour | — | — | — | 0·10 | — | 0·10 | 0·25 | 0·69 | 0· |
| 22. Education | 5·17 | 0·83 | 6·00 | 4·70 | 1·97 | 6·67 | 0·05 | — | 0· |
| 23. Health-ICMR | 1·49 | 3·81 | 5·30 | 2·10 | 4·05 | 6·15 | 9·50 | 16·00 | 25· |
| 24. Social Welfare | — | — | — | — | — | — | 4·89 | 4·30 | 9· |
| 25. Rural Reconstruction | 0·73 | — | 0·72 | 0·88 | — | 0·88 | — | — | — |
| 26. Agr. ICAR | 47·65 | 20·26 | 67·91 | 53·07 | 32·85† | 85·92 | 0·88 | — | 0· |
| Agr. FRI | 0·90 | — | 0·90 | 1·25 | — | 1·25 | 59·97 | 36·39 | 96· |
| 27. Food | 0·47 | 0·45 | 0·92 | 0·91 | 0·49 | 1·40 | 2·00 | — | 2· |
| 28. Irrigation | 0·72 | — | 0·72 | 1·00 | — | 1·00 | 1·16 | 0·49 | 1· |
| 29. Railways (PDSO) | — | 5·75 | 5·75 | — | 6·36 | 6·36 | 1·23 | — | 1· |
| | | | | | | | — | 6·00 | 6· |
| TOTAL 'B' : | **93·80** | **63·75** | **157·55** | **117·52** | **90·40** | **207·92** | **141·15** | **110·92** | **252·** |
| GRAND TOTAL | **190·88** | **172·51** | **363·39** | **207·44** | **222·33** | **429·77** | **257·52** | **257·13** | **514·** |

*For Deptt. of Textiles, included under Deptt. of Industrial Development upto 1979-80

†1979-80 (RE)

*Note* : For 1979-80, data in respect of Part A relates to Actuals and for Part B, it relates to RE; Data for Part B for 1980-81 ar tentative.

**Rate of growth of S&T Exp. between 1974-75 & 1980-81**

| | 1974-75 (Rs. crores) | 1980-81 (Rs. crores) | Average Rate of Growth per year 1974—81 | 1978-79 (Rs. crores) | Average rate c growth 1974—7 |
|---|---|---|---|---|---|
| **Plan** | | | | | |
| (*i*) Agencies | 49·11 | 116·70 | 15% | 97·08% | 18% |
| (*ii*) Agriculture (ICAR) | 14·60 | 59·49 | 26% | 47·65 | 34% |
| (*iii*) Others | 12·50 | 80·48 | 36% | 46·15 | 38% |
| TOTAL | 76·21 | 256·67 | 23% | 190·88 | 26% |
| **Non-Plan :** | | | | | |
| (*i*) Agencies | 75·39 | 141·39 | 11% | 108·76 | 9·5% |
| (*ii*) Agriculture (ICAR) | 14·15 | 32·85£ | 18% | 20·26 | 9·5% |
| (*iii*) Others | 17·59 | 61·49 | 23% | 43·49 | 25% |
| TOTAL | 107·13 | 235·73 | 14% | 172·51 | 12·5% |
| **Plan+Non-Plan** | | | | | |
| (*i*) Agencies | 124.50 | 258·09 | 13% | 205·84 | 13·5% |
| (*ii*) ICAR | 28·75 | 92·34 | 22% | 67·91 | 24% |
| (*iii*) Others | 30·09 | 141·97 | 30% | 89·64 | 31% |
| TOTAL | 813·34 | 492·40 | 18% | 363·39 | 19% |

£1979-80 (RE).

TABLE 2

FIVE YEAR PLAN 1978—83—S&T OUTLAYS

(Rs. crores)

| Sl. No. | Agency/Deptt./Ministry | Fifth Plan 1974—79 (Plan Outlay) | Plan 1978—83 (Plan Outlay) | Non-Plan 1978—83 (Outlay) |
|---|---|---|---|---|
| A. | **S&T Agencies** | | | |
| 1. | Atomic Energy (R&D) | 167 ·13 | 220 ·00 | 210 ·00 |
| 2. | Space | 128 ·27 | 210 ·00 | 116 ·00 |
| 3. | DST | 58 ·96 | 110 ·00 | 145 ·00 |
| 4. | CSIR | 81 ·77 | 110 ·00 | 162 ·00 |
| 5. | National Test House ((Supply) | 2 ·10 | 4 ·48 | 3 ·50 |
| | TOTAL 'A' | **438 ·23** | **654 ·48** | **636 ·50** |
| B. | **S&T Component under Ministries/Departments** | | | |
| 6. | Heavy Idustry | 28 ·76 | 49 ·91 | 60 ·00 |
| 7. | Industrial Development | 10 ·74 | 20 ·25@@ | 10 ·00 |
| 8. | Steel | 6 ·62 | 32 ·78 | 1 ·00 |
| 9. | Mines | 6 ·48 | 18 ·00 | — |
| 10. | Power | 8 ·69 | 20 ·00 | 4 ·10 |
| 11. | Coal | 6 ·39 | 18 ·00 | 13 ·28 |
| 12. | Petroleum | 12 ·08 | 31 ·98 | 17 ·61 |
| 13. | Chemicals & Fertilizers | 2 ·35 | 16 ·00 | 3 ·50 |
| 14. | Electronics | 18 ·73 | 30 ·00 | 5 ·00 |
| 15. | Communications | 22 ·39 | 34 ·11 | 24 ·21 |
| 16. | I&B | 0 ·77 | 2 ·00 | 1 ·50 |
| 17. | Shipping & Transport | 2 ·98 | 23 ·74@ | 3 ·48 |
| 18. | TCA-IMD & Institutes | 19 ·58 | 50 ·00 | 60 ·00 |
| | R&D Dte. C.A. | 0 ·38 | 1 ·00 | 0.80 |
| 19. | Works & Housing | 0 ·53 | 1 ·50 | 3 ·60 |
| 20. | Labour | 0 ·15 | 0 ·50 | — |
| 21. | Education | 35 ·50 | 30 ·00*** | 16 ·00*** |
| 22. | Health-ICMR | 21 ·32 | 12 ·00* | 21 ·44 |
| 23. | Social Welfare | — | 2 ·52 | — |
| 24. | Rural Reconstruction | 1 ·21 | 5 ·50 | — |
| 25. | Agriculture—ICAR** | 153 ·56 | 300 ·00 | 155 ·00 |
| | —FRI | 4 ·70 | 11 ·10 | — |
| 26. | Food | 3 ·20 | 5 ·70 | 2 ·50 |
| 27. | Irrigation | 8 ·48 | 5 ·41 | — |
| 28. | Railways (RDSO) | — | — | 30 ·00 |
| | TOTAL 'B' | **375 ·59** | **721 ·95** | **433 ·02** |
| | GRAND TOTAL | **813 ·82** | **1376 ·43** | **1069 ·52** |

*Tentative.

**Including Education and Training.

***Estimated provision for grants-in-aid to Universities by UGC.

@Includes Rs. 12 ·14 crores for ship-building industry.

@@L&M—14 ·25 crores, SSI—3 ·00 crores, Coir—3 ·00 crores.

Note :—

(i) Includes plan outlays for operational programmes of Survey of India, NRDC and IMD, grants-in-aid by ICAR to Agricultural Universities. Excludes operational programmes of Geological Survey of India and outlay for research in rubber, coffee, sericulture etc.

(ii) The non-plan outlays include estimated recurring expenditure to be met from internal resources of public sector undertakings.

No. M. 12018/83/80-S&T
GOVERNMENT OF INDIA
PLANNING COMMISSION

Yojana Bhavan,
Parliament Street,
New Delhi-110001.

Dated 12th September, 1

## OFFICE MEMORANDUM

**Sub :—Core Working Group on Science & Technology for the Five Year Plan (1980—85)**

In the context of the preparation of the Five Year Plan (1980—85), it has been decided to set up an integrated Working Gro on Science & Technology. The composition and terms of reference of the Group are as follows :

**(*i*) Composition**

| | | |
|---|---|---|
| 1. | Prof. M. G. K. Menon,<br>Secretary,<br>Department of Science & Technology. | Chairn |
| 2. | Prof. B. M. Udgaonkar,<br>Tata Institute of Fundamental Research,<br>Bombay. | Mem |
| 3. | Prof. Y. Nayudamma,<br>Distinguished Scientist,<br>Madras. | Mem |
| 4. | Dr. S. Varadarajan,<br>Chairman and MD,<br>IPCL, Baroda. | Mem |
| 5. | Prof. Rais Ahmed,<br>Vice-Chancellor,<br>Kashmir University,<br>Srinagar. | Mem |
| 6. | Dr. H. K. Jain,<br>Director,<br>IARI, New Delhi. | Mem |
| 7. | Prof. G. P. Talwar,<br>Jawaharlal Nehru Fellow,<br>AIIMS, New Delhi. | Mem |
| 8. | Shri T. R. Satishchandran,<br>Adviser (Energy),<br>Planning Commission. | Mem |
| 9. | Shri M. Satyapal,<br>Adviser (I&M),<br>Planning Commission. | Meml |
| 10. | Dr. G. Rangaswamy,<br>Adviser (Agri.),<br>Planning Commission. | Meml |
| 11. | Shri Lav Raj Kumar,<br>Chairman,<br>Bureau of Industrial Costs & Pricing,<br>New Delhi. | Mem |
| 12. | Shri M. R. Raman,<br>Joint Adviser (S&T),<br>Planning Commission. | Member-Conver |

(ii) **Terms of Reference**

1. To recommend a policy framework for the S&T priorities for the Plan 1980—85.
2. To suggest specific mechanisms for strengthening the following linkages :
   (*a*) Academic/educational institutions with national laboratories,
   (*b*) Academic institutions with industries,
   (*c*) National laboratories with industries,
   (*d*) National laboratories/academic institutions with user departments,
   (*e*) User departments and scientific institutions with Planning Commission.
3. To review the existing organisational structures/system for S&T planning, coordination, Implementation, monitoring and evaluation and suggest the manner in which the role and structure of NCST, S&T Div. (Planning Commission) and S&T cells in administrative Ministries should be strengthened/reorganised.
4. To recommend on incentives, amenities and facilities needed by the scientific community for effective functioning.
5. To recommend on proper and full utilization of scientific manpower.
6. To suggest the methodology for adopting an integrated approach in areas in which several agencies/laboratories are operating.
7. To suggest areas of priorities for S&T effort in the several sectors of the socio-economic Five Year Plan (list of sectors given in Annexure I), and further identify major areas for coordinated research thrust in the Five Year Plan, demarcating clearly the scope of work of the participating agencies.
8. To recommend on the methodology and the setting up of new institutions in the field of S&T to ensure self-reliance on a long-term continuing basis.
9. Identify requirements of S&T inputs/needs specific to the sectors (Annexure I refers); and recommend broadly the programme content and outlays (Plan/Non-Plan) required by the different implementing/participating agencies/organizations/Departments.

2. The Working Group is expected to give its report in two Phases. Phase I of the report is expected to be furnished by 26th Sept. 1980, covering the policy framework, issues and structures, priority areas and major/important programmes together with indicative outlays for the different sectors/Departments.

3. For a more detailed exercise in second Phase, Sub-Groups relevant to the component sectors of the Plan are expected to be set up to assist the Core Working Group.

4. The expenditure on TA/DA in connection with the meetings of the Working Group will be borne by the parent Departments/Ministries/Organizations to which official members belong. Non-official members will be entitled to TA/DA as admissible to Grade I officers of the Govt. of India and this will be paid by the Planning Commission.

5. Any correspondence regarding, this Working Group may kindly be addressed to Member-Convenor.

Sd/-

(Y. Mohan)
Director (Admn.)

To,

Chairman and all Members of the Working Group.

**A list of sectors/sub-sectors pertaining to S&T Plan**

1. **Energy :**

   (*i*) Coal, Petroleum and Alternative Sources of Energy.

   (*ii*) Power and Atomic Energy.

2. **Industries :**

   (*i*) Machinery, Tools, Instrumentation Development, Electronics and Steel Industries.

   (*ii*) Mining, Minerals, Non-Ferrous Metals and Ocean Resources industries.

   (*iii*) Consumer Industries (Textiles, jute, synthetics, sugar, paper, leather and ceramics), Small Scale and Village Industries.

   (*iv*) Chemical Industries (including fertilizers, drugs, insecticides, pesticides, petrochemicals and polymers, catalysts and corrosio

3. **Communication & Broadcasting :**

   (Tele-Communication; Satellite Communication/Space Science & Technology; Broadcasting (Wireless & TV).

4. **Agriculture & Bio-Sciences :**

   (*i*) Agriculture Research & Education, Forestry, Animal Husbandary. Fisheries and Remote Sensing Applications,

   (*ii*) Irrigation & Meteorology.

   (*iii*) Biosciences and Biotechnologies , Natural plant products, Ecology and Environmental Sciences.

5. **Transport :**

   (*i*) Shipping, Road & Ports, offshore facilities, Railways and Aeronautics.

6. **Basic Research, Education & Training :**

   (*i*) Support for technical education, refresher/retraining, Societies, Academies/Professional institutions, grant-in-aid fundi and information science/systems.

7. **Social Welfare :**

   (*i*) Housing, Urban Development and Rural Reconstruction (village industries, small industries etc.), Labour and Mines Safet

   (*ii*) Food & Nutrition, Health and Allied Health Education and Water Supply.

*Appendix II*

No. M. 12018/83/80-S&T

GOVERNMENT OF INDIA

PLANNING COMMISSION

Yojana Bhavan, Sansad Marg,
New Delhi, the 15*th Sept*. 1980.

## OFFICE MEMORANDUM

*Subject :* Core Working Group on Science & Technology for the Five Year Plan (1980—85).

In partial modification of O.M. of even No. dated 12th September, 1980 it has been decided that the Composition of the Core Working Group would be as follows :

**(i) Composition**

| | | |
|---|---|---|
| 1. | Prof. M. G. K. Menon, Secretary, Department of Science & Technology, New Delhi. | Chairman |
| 2. | Prof. B. M. Udgaonkar*, Tata Institute of Fundamental Research, Bombay. | Member |
| 3. | Prof. Y. Nayudamma, Distinguished Scientist, Central Leather Research Institute, Madras. | Member |
| 4. | Dr. S. Varadarajan, Chairman and Managing Director, Indian Petrochemicals Corporation Ltd., Baroda. | Member |
| 5. | Prof. Rais Ahmed, Vice-Chancellor, Kashmir University, Srinagar. | Member |
| 6. | Dr. H. K. Jain, Director, Indian Agricultural Research Institute, New Delhi. | Member |
| 7. | Prof. G. P. Talwar, Jawaharlal Nehru Fellow, All India Institute of Medical Sciences, New Delhi. | Membe |
| 8. | Shri Lav Raj Kumar, Chairman, Bureau of Industrial Costs & Pricing, New Delhi. | Member |
| 9. | Dr. G. S. Siddhu, Director, Regional Research Laboratory, Hyderabad. | Member |
| 10. | Shri A. Rahman, Chief (Planning), Council of Scientific & Industrial Research, New Delhi. | Member |

*Attended the first meeting and later expressed inability to continue.

11. Secretary,
Department of Electronics.
Lok Nayak Bhavan,
New Delhi. — Mer

12. Secretary,
Defence Research & Development,
New Delhi. — Mer

13. Chairman,
Atomic Energy Commission,
Bombay. — Mer

14. Chairman,
Space Commission,
Bangalore. — Men

15. Director General,
Indian Council of Agricultural Research,
New Delhi. — Mem

16. Director General
Indian Council of Medical Research,
New Delhi. — Mem

17. Vice Chairman,
University Grants Commission,
New Delhi. — Meml

18. Shri T. R. Satish Chandran,
Adviser (Energy)
Planning Commission. — Meml

19. Shri M. Satyapal,
Adviser (I&M),
Planning Commission. — Memb

20. Dr. G. Rangaswamy,
Adviser (Agriculture),
Planning Commission. — Memb

21. Shri M. R. Raman,
Joint Adviser (S&T),
Planning Commission. — Member-Convenc

(ii) The terms of reference etc. will remain the same.

Sd/-
(Y. Mohan)
Director (Admn.)

To,

Chairman and all Members of the Working Group.

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